$3 A YEAR

PRODUCT ENGINEERING

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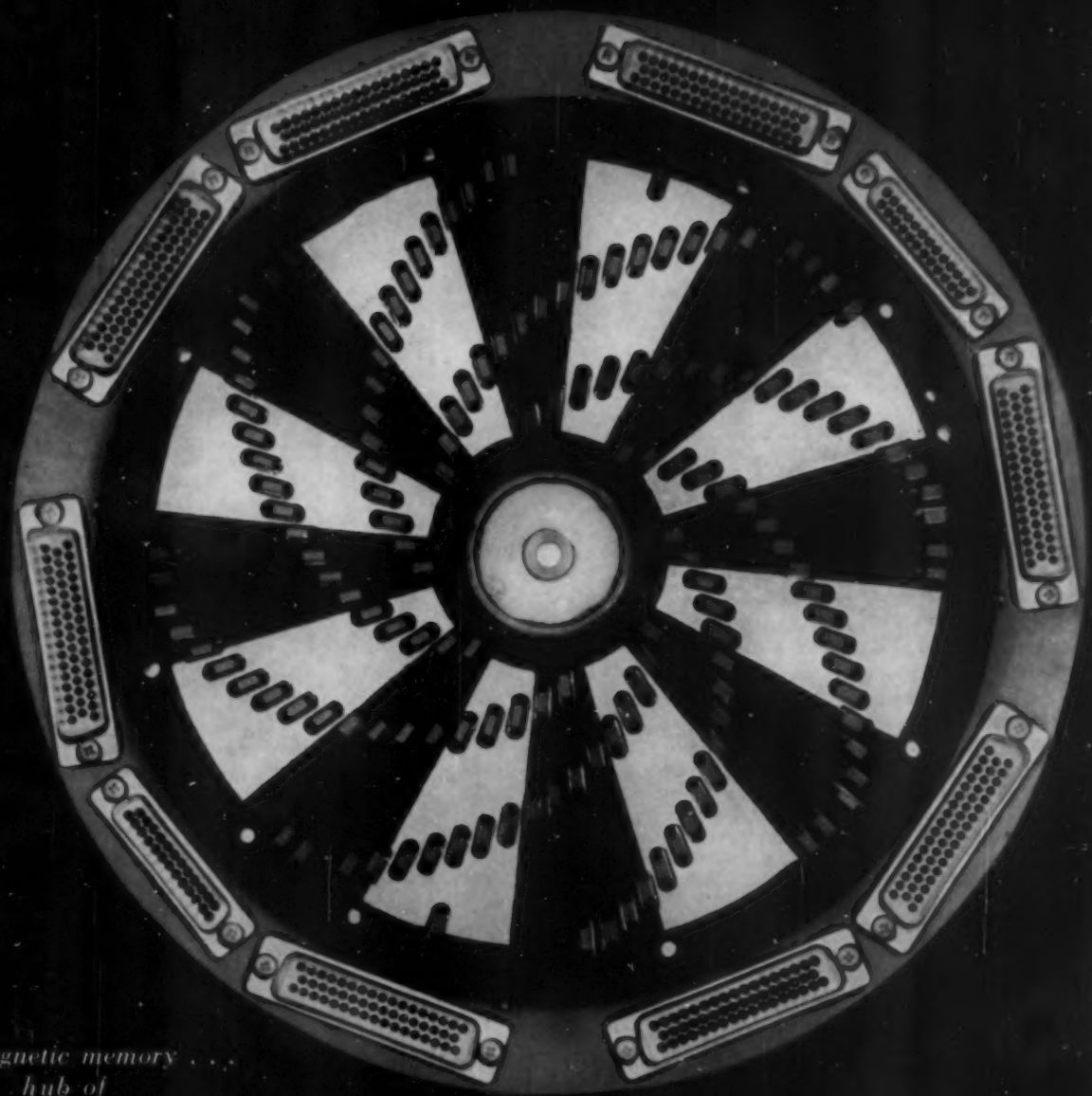
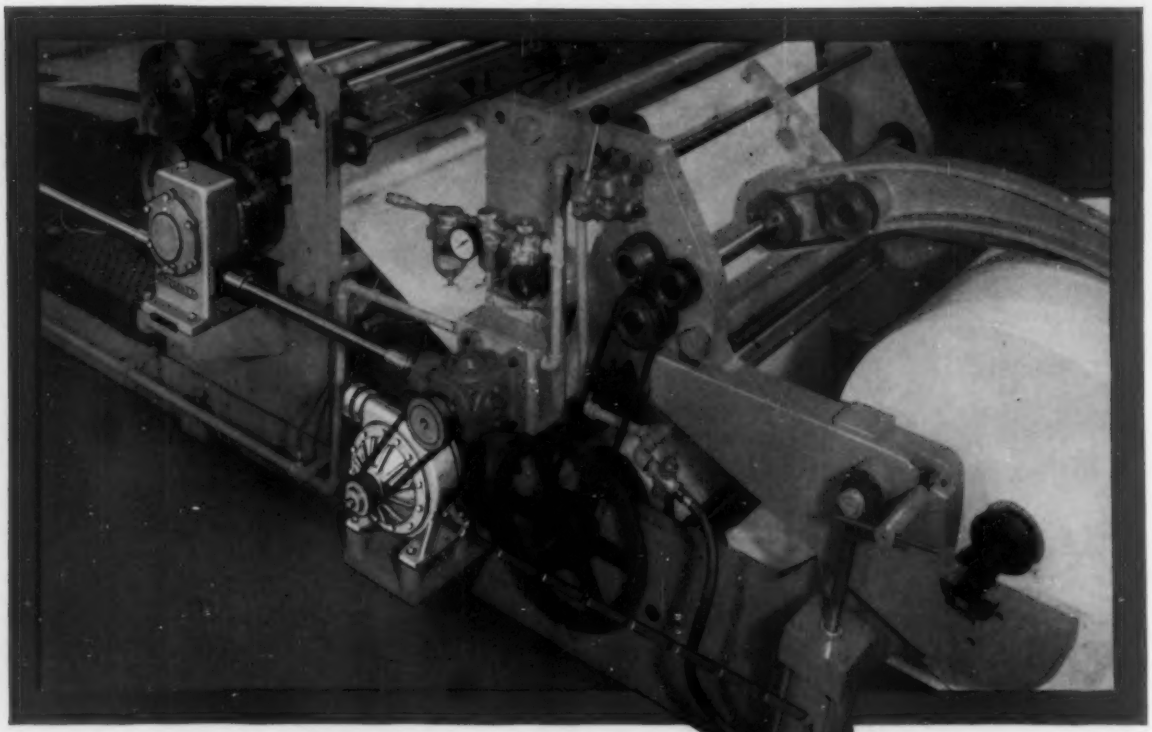


Magnetic memory . . . hub of

THE DESK-SIZE DIGITAL COMPUTER

How to choose and operate these engineering problem solvers . . .

see page 13



Cleveland Speed Variator accurately controls paper web fed into Schriber Printing Press

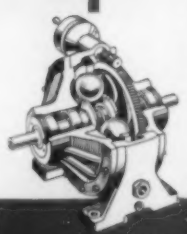
This new Rotary Offset Business Forms Press built by Schriber Press Company of Dayton, Ohio, was designed to provide printers with more hourly impressions—more daily output.

Its new infeed web tension control drive gives absolute constant tension from mill roll through a Cleveland Speed Variator-driven metering cylinder to press.

The Variator compensates for paper thickness—maintains constant surface speed of paper to the press—guarantees finished printing will always stay "in register".

A modified Cleveland Speed Variator providing increased precision within a limited (± 25%) range was selected for this important function. This was accomplished by changing the curve of Variator's iris plate. Thus, this Variator allows exacting adjustment for paper machine tension—holds that tension or can easily be changed to another speed setting.

If your operations demand speed variation, be sure to get the complete "Cleveland Speed Variator Story". It's all in free Bulletin K-200 —write for your personal copy today.



HOW IT WORKS

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view, left).

Cleveland Worm & Gear Division
Eaton Manufacturing Company
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CLEVELAND SPEED VARIATOR

CIRCLE 201 ON READER SERVICE CARD

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

April 11, 1960 Vol. 31, No. 15

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FOR AUTOMATIC COFFEE MAKERS

Type B top; Type A center; Type S bottom. Other designs available.

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No wonder leading manufacturers of automatic coffee makers specify Stemco thermostats. For Stemco thermostats give long-life reliability that eliminates service headaches . . . are quickly, easily installed . . . are competitively priced. Our application engineering service is eager to help you solve your thermostatic control problem, whether it involves design, production or cost. Try us *now*.

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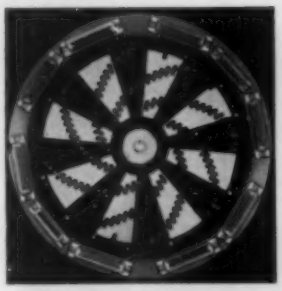
INTERESTING TO NOTE

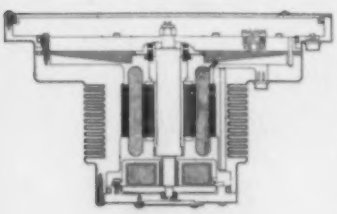
The Computer Story— from Census Gains to Gambling Losses



"Used with understanding, a computer can make the designer more effective, more certain, and perhaps also more enterprising. Design has always been a field of so-called 'inspired guesswork', and its methods have often been (and may in some directions remain) empiric. This has sometimes been due to the sheer labor of elucidating anything like a rigid solution to a given problem."

—PROF M. G. SAY, *University of Edinburgh*

Speaking of computers, below is a cross-section of the magnetic-disk memory unit on our cover. The disk is mounted to its shaft with a flexible diaphragm so that it is free to align itself with the plate carrying the magnetic heads. Proper separation between heads and disk is maintained by hydrodynamic air pressure created by disk rotation. The shaft is spring-loaded away from the heads until full speed (3450 rpm) has been reached. At this point the solenoid at the bottom pushes the disk up toward the headplate. The assembly is the memory unit of the Autonetics Recomp II computer (see page 43).



This month, computers will take on a monumental task. Every 10 years, says our Constitution, the Federal Government must count America's noses; and the big count is ready to begin again. In the old days the census was a seven-year operation; now, thanks to computers, the whole job can be done in less than a year. The big break came in 1880 when Dr Herman Hollerith, mathematician and special Census Bureau agent, realized that although our population had grown by more than 10 million in 10 years, our pencil-and-paper tabulation methods had not changed since the census' inception. For seven years Dr Hollerith worked on a system to mechanize a data-processing method and to help him, he had the work of two pioneers—Charles Babbage and Joseph Jacquard.

In 1812, Englishman Babbage, conceived a mechanical device to perform calculations that would be ambitious even for today's electronic computers. To demonstrate his idea, Babbage built a model with 18 wheels, able to compute tables up to five places. In 1822, sponsored by Sir Humphry Davy, he won aid from the British government to design and construct a full-size machine, to handle numbers with as many as 20 digits. Babbage had to invent not only many of the parts for his computers, but also the machines to make them. After many years' work, the government withdrew support from Babbage's project. His 239 detailed engineering drawings included plans for 50,000 parts and the punched card, which he adapted from the Jacquard looms invented a few years earlier.

From the computer of Babbage and the punched-card

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Charles Babbage, 1792-1871

concept of Jacquard, Dr Hollerith developed a system of recording, tabulating and analyzing information. By punching holes in cards to correspond with specific census questions and answers, it was possible to register data by an electric mechanism. With the new machines, the census compilations made their first big gain—two years instead of seven.

Today, the computer has come into its own, and on page 43 our special report tells how to choose and operate the new desk-size problem-solvers.

Computers were first designed as an aid to scientists, engineers and businessmen. Recently they've been applied to some rather unusual tasks. For example, a lady in New York City has opened a dating bureau that tries to match suitable couples by using punched cards. In Los Angeles, Richard E. Trueman of UCLA recently told the Operations Research Society of America that an IBM 709 computer has been instructed how to manage a baseball team. The machine decides whether a sacrifice, stolen base or intentional walk is the best strategy under given conditions.

In the field of literature, computers have become a valuable aid to scholars. Preparing concordances of noted literary works often took years; with a computer this time is sharply cut. In 1894, James Strong spent 30 years preparing a concordance for the King James Version of the Bible. Recently, a computer aided in the preparation of a concordance to the Revised Standard Version. It took less than two years—machine time was only 1000 hours.

Showing its respect for science, one of Las Vegas' gaming spots, the Hotel Showboat, has brought in a Univac 120 to assist gamblers. The computer has been fed the basic situations encountered in games of dice, roulette and "21." (As an example of the magnitude of the job, 60,000 hands of "21" were played through the computer in order to evolve a handy chart for the player's use.) Having worked out a law of averages for the player, the hotel's management had the information printed on cards and distributed to patrons of the casino. Dice, roulette or "21" players take these strategy charts with them to the tables, and by following instructions, know when their chances are best to put their chips down.

In addition, patrons are invited to take any situation not covered by the charts and submit it to the computer for an answer. They are also invited to ask the computer the always-tormenting question — whether to quit or not. This is handled on a basis of income and budget. Again by using punched cards, the gambler is told, in exact dollars, at what point to cut losses or to pocket winnings.

The hotel makes no bones about who's going to win in the long run. But losing with the computer at his side gives the loser the satisfaction of knowing he played the odds right.

—Benedict A. Leerburger, Jr.

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Zinc Die-casting Cuts Cost**

For small parts, the inexpensive single-cavity method gives up to 300 parts per minute.

. . . **Where Do You Fit In?**

A road map for engineering—how a product moves through departments as each group of men adds to the idea.

. . . **3-D Harness Wiring**

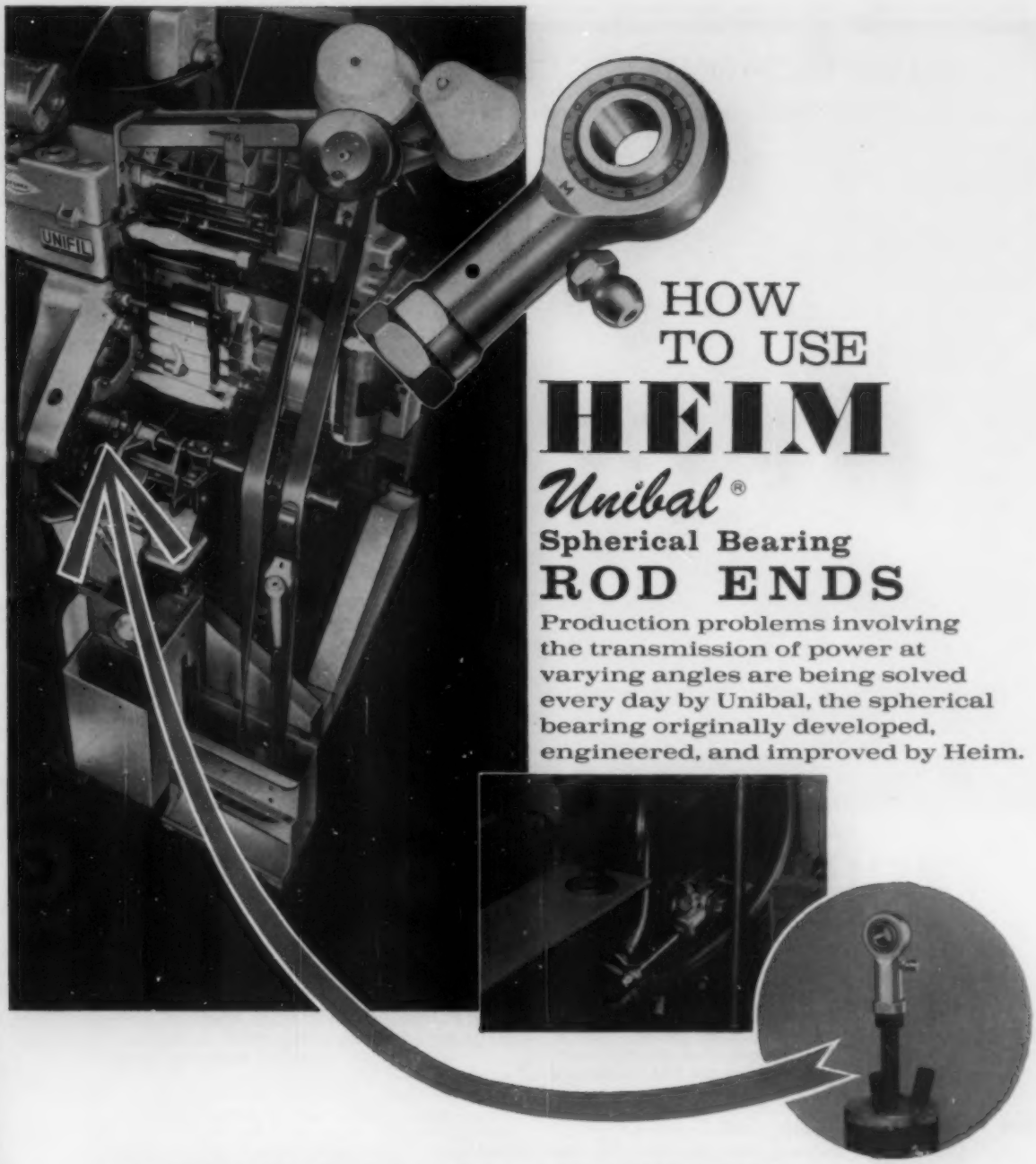
Once the basic circuits have been designed, this new technique takes over —with punched cards, mockups, and cameras that record the final assembly.

. . . **How Practical Is Nonlinear Programming?**

An introduction to nonlinear programming—still the only way to crack many familiar problems.

. . . **Engineering Management—a Division of Responsibilities**

A growing source of trouble to top management, engineers and researchers may be narrowed and controlled by this simple suggestion.



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Production problems involving the transmission of power at varying angles are being solved every day by Unibal, the spherical bearing originally developed, engineered, and improved by Heim.

It is used here as a component of the air pump assembly on the Unifil® Loom Winder made by Leesona Corporation of Providence. This machine is united with the loom to wind the quills, transfer them to the shuttle, strip and return empties to the winder for uninterrupted weaving production. The Unibal Rod End is threaded onto the end of the air pump piston rod, and provides the necessary freedom for an up and down action. Unibal also reduces the skill necessary for a perfect lateral alignment.

Heim, and its sales engineers are ready to offer you any assistance in adapting Unibal to your particular needs. Please write for complete catalog.

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DEVELOPMENTS TO WATCH...

New sponge rubber is strong, weather-resistant

A polyethylene-butyl rubber, open-cell sponge that's said to be 3 to 10 times as strong as standard butyl sponge is claimed by three Esso research engineers. They say it has a tensile strength of 100 to 150 psi, resists sunlight, ozone, strong acids (including fuming nitric), and can be made in thin sheets. Technical information may be obtained from Enjay Corp, Esso Research affiliate.

Flameproof fluorocarbon being readied for production

A nonflammable CTFE (chlorotrifluoroethylene) thermoplastic, with high heat and chemical resistance, good electrical properties, and low moisture absorption, is promised by Allied Chemical Co's General Chemical Div as the first product from a new fluorocarbon plant to be built at Baton Rouge, La. In addition, the company says, the new plastic has excellent transparency, can be fabricated by a wide range of molding methods and is readily machinable. Temperature range is —100 to 400 F.

The material is now in pilot-plant production and is available in limited quantities for evaluaton in molding powder and film form. Commercal production is expected to begin about the first of next year.

Improved lubricants under test in Canada

Lubricating greases with excellent water resistance, good storage life and low-temperature properties are now being made from rapeseed oil. And, says Canada's Saskatchewan Research Council, they pass all standard wheel-bearing and bleeding tests.

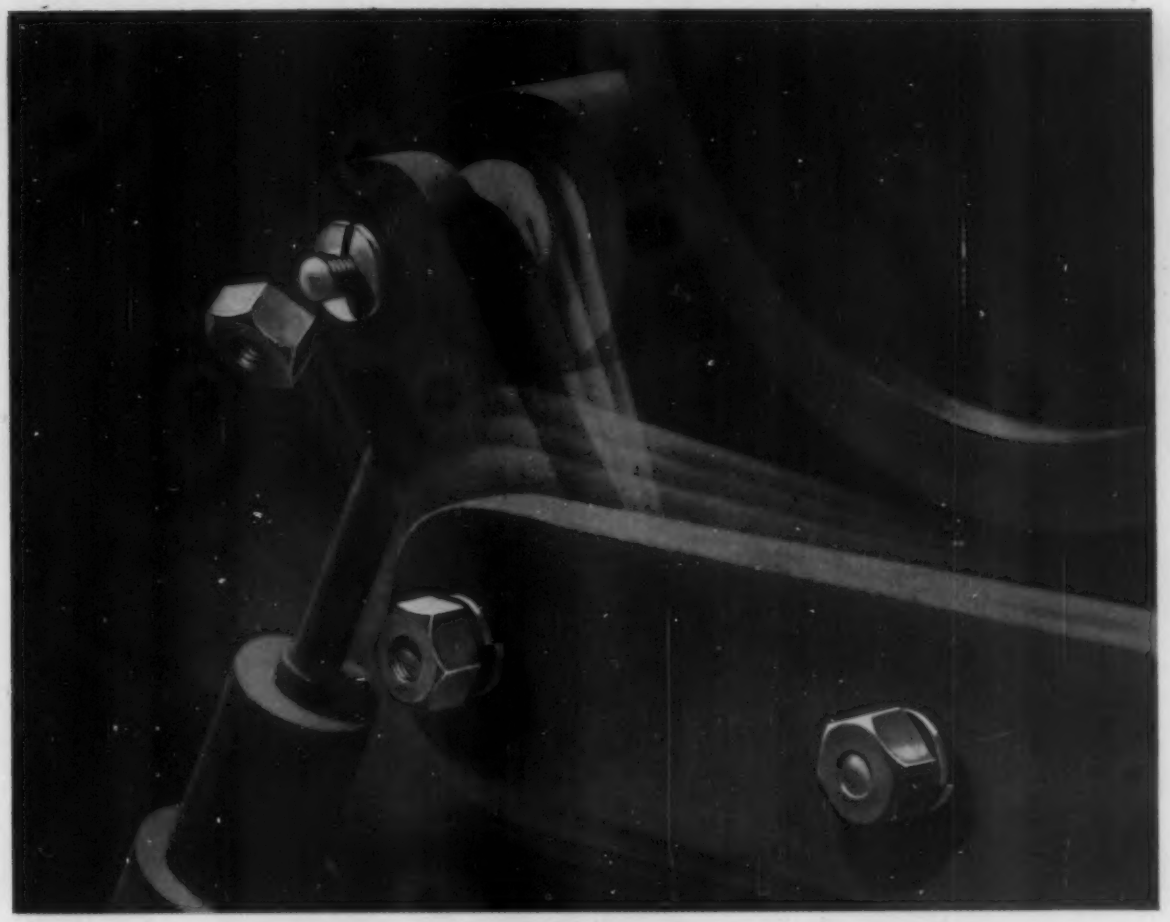
First of a new family of rapeseed oil-based lubricants being developed in Canada (*PE*—June 30 '58, p 6), these greases are being produced in substantial quantities and are now undergoing market tests. Their shear stability is not quite up to standard, but research is continuing and there is every expectation that this property can be improved.

Farther from commercial production, but showing up very well in tests are rapeseed oils. Added to standard lubricants, they appear to promote oil flow at low temperatures, improve detergency, and reduce engine wear. Blends containing approximately 10% rapeseed oil could, SRC believes, be produced in quantity at a price competitive with high-grade diesel oils. Such blends are now under test in automobiles, farm equipment and other vehicles; but no plans have yet been made for commercial production of the blends.

Sun to light up Japan Sea

Pictured here is the first of six solar-powered lighthouses, being built for Japan's Maritime Agency, in which a silicon energy-conversion system will be used to charge nickel-cadmium batteries that supply power to the flashing light. The solar-cell system, designed by Nippon Electric Co, consists of a 648-cell panel, supplying a 12-v, 15-w nickel-cadmium battery which, in turn, powers a flashing 10-w bulb. Preliminary tests indicate that there is sufficient sunlight to keep the battery charged, and that the system will permit continuous operation.

SOLAR PANEL can be seen mounted atop Japanese lighthouse. Individual cells are mounted on plastic boards in groups of 9 each.



30 SECONDS TO FAILURE!

—and somebody's reputation is shaking

When pounding vibration shakes loose common fasteners like these, critical working parts of a product usually fail. When this happens, the reputation of the manufacturer is shaken, too.

Elastic Stop® nuts will not shake loose. Each nut uses the exclusive red nylon locking insert to provide a continuing locking torque which absorbs impact and shock loads and holds under the most severe operating conditions. In the long run, it is exactly this capacity to lick vibration-induced failure that makes Elastic Stop nuts the most economical fasteners you can buy.

Elastic Stop nuts cost only a little more than the combination of fasteners used here. But can you afford the *real* price of any low-cost fastener that fails to provide reliability? For it's precisely this type of false economy that ruins reputations when customers incur costs for repairs, downtime and loss of production. As a matter of fact, the cost of extra field service may wipe out the manufacturer's profits, too.

Detailed photos are available showing exactly how Elastic Stop nuts solve critical fastening problems on rock drills, scrapers, snow plows, off-the-road trucks and other heavy equipment. You can see these photos simply by writing to us. Or, we can send you test samples of the fastener sizes you need. Just write: *Dept. S42-445, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.*

Elastic Stop nuts offer 3 important design advantages:

Precision adjustment at any point on the bolt

Prevent leakage along bolt threads

Nylon locking insert is re-usable 50 times or more

ELASTIC STOP NUT CORPORATION OF AMERICA

More mesa transistors coming

Two new lines of silicon mesa transistors—one medium power (5 to 50 w) and one power (50 w and above) group—will be introduced by National Semiconductor before the end of this year. These are in addition to the VHF line for computers, video amplifiers and related applications announced just last month (*PE*—Mar 28, p 6). Like the VHF group, the new ones are expected to feature small size, low leakage currents and a wide operating-temperature range.

Tungsten ductility may be improved by arc-melting, extrusion

Tungsten rods produced by arc-melting and extrusion show promise of improved ductility as compared to material produced by conventional powder-metallurgy techniques, NASA's Lewis Research Center reports. Initial tests of expanded tungsten show ductile rather than brittle-type fracture (the specimens "neck" rather than breaking sharply), and considerable evidence of grain refinement.

The studies here are still in their early stages; but, the LRC report, combined with development of improved spinning and forging techniques (*PE*—Nov 11 '57, p 9 and Apr 6 '59, p 16), recent reports on calcium-reduced tungsten that can be hack-sawed and hammer-forged (*PE*—Feb 8, p 8) and single crystals that are ductile at room temperature, indicate that this intractible metal may soon bow to advancing technology.

Yttrium improves refractory metals

Additions of rare-earth element yttrium can help refine the grain of chromium, titanium, and zirconium; and may have a similar effect on copper and iron, USSR metallurgists Y. M. Savitskii and V. F. Terekhova report. It also has a deoxidizing effect, they say; and it hardens aluminum and magnesium.

Apparently, the Soviets have a major research program under way on this and related metals—scandium and the rare earths—and are developing a technology comparable to our own. A major report on US work with these metals, and their potential engineering applications will appear in PRODUCT ENGINEERING soon.

New adhesives and thickening agents from agricultural research

Materials made from corn sugar by a process similar to fermentation promise improved adhesives and other materials for industrial use. One of these new compounds, a polysaccharide gum known as phosphomannan is a water-soluble material that forms a cohesive gum when concentrated, "brilliantly clear, thixotropic solutions with a soft gel-like aspect" when treated with borax and potassium chloride. It is, says USDA's Northern Utilization R & D div, "unlike any other substance heretofore available in certain of its properties . . .

"Uniquely, the viscosity at 1.5 and 5.25% concentrations is greater than at 3%." Its thixotropic properties (ability to flow when worked; but hold its position, when left alone), while not unique, are also most interesting.

Research samples of this and a related polysaccharide (B-1459) are now available from the USDA laboratory at Peoria, Ill, and commercial possibilities are being explored. —ARG

NEW GUM is a viscous, cohesive material (left) that can be turned into a soft, clear gel (right) by chemical treatment.

WHAT'S HAPPENING IN RESEARCH . . .

Metal fibers improve nuclear fuels

Close on the heels of reports of glass-fiber fuel elements for nuclear reactors (*PE*—Mar 14, p 8) comes one from Martin Co's Nuclear Div on elements of metal-fiber and uranium dioxide. In this case, the fibers are molybdenum, and they are incorporated in a uranium dioxide ceramic composition, swaged to rods with a density of approximately 90%.

Reason for using the fiber: to improve thermal conductivity and aid in heat removal. Addition of 15% of molybdenum fiber (by volume) improves thermal conductivity 30% at room temperature and even more at elevated temperatures; and larger amounts of fiber promise to do even better.

(In contrast, glass fibers are used as fuel carriers, with the uranium dioxide being incorporated in the glass as it is made. They have no function in heat removal.)

Three preliminary reports on this study are now being made available through OTS, Dept. of Commerce, Washington 25, DC; and a final roundup is being prepared for publication. (The earlier reports, covering work from Dec 1958 to Oct 1959 are MND-SF-1714, 1768, and 1769. Prices: $1, $1.50, $1.75. The final one will be MND-SF-1770.)

Microwaves to power space vehicles?

A helicopter held aloft, at an altitude of 10 to 15 mi, by radio power is envisioned by Raytheon engineers; and, they say, serious design work is already under way. They think 60 superpower tubes, delivering 12,000 kw, could do the job.

This is by no means beyond the realm of possibility; 500-kw magnetrons are already available. New tubes are under development; among them, Raytheon's own Amplitron. W. C. Brown of Raytheon says recent modifications which permit a 10-fold increase in its input and rf-output levels make it look especially attractive for space-power purposes.

Such a helicopter, or a series of microwave-supported space platforms, could be used for surveillance or as a communications relay station. For actual space travel though—beyond the earth's atmosphere, he does not believe earth-broadcast microwave power would be practical. The problem of pinpointing the beam alone would be almost insuperable.

As to the helicopter itself, it would consist of a 50-ft-diameter receiving antenna made up of a number of smaller antennas, each independently connected to a resistive load. This would make the full array less directive, so that changes in attitude will not cause loss of power.

The resistive load would be part of a heat exchanger, which would heat the working fluid of either an open- or a closed-cycle gas turbine engine.

A supplementary chemical fuel would be used to carry the craft to the desired altitude.

Protecting steel from acid attack

Additions of chromium, nickel, molybdenum, and copper can markedly increase resistance of steel to sulfuric acid, says a Soviet report relayed by a French translator. But columbium and titanium have little or no beneficial effect.

The steels tested by the Soviet researchers contained 5 to 30% Cr and Ni, 0 to 3% Cu and Mo, 0 to 1.5% Cb and 0 to 0.5% Ti.

In general, they say, two-phase (austenite-martensite) stainless steels show considerably better corrosion resistance in 30% acid at 150 F than do the single-phase austenitic alloys. Detailed results are contained in a report by E. V. Zotova in the Soviet publication *Khim Prom.*

briefs . . .

Pictures that develop themselves are under study at Technical Operations Inc for the Air Force. These are photographic systems using photosensitive resins that polymerize when exposed to light. Once polymerization occurs, no further processing is needed—making it possible to obtain "instant" pictures. TOI plans to evaluate several such processes, report on their practicality for aerial reconnaissance. It will also explore possible industrial applications.

Vacuum-melted metal gets another pat on the back from NASA's Lewis Research Center with release of a report on high-temperature tests of nickel-base "super-alloy" (GMR 235) gas turbine buckets. Says LRC: "vacuum-melted buckets had better than twice the life (based on time-to-fracture) of air-melted buckets." Vacuum-melted samples lasted more than 250 hr; air-melted, about 100 hr.

The practical value of the results is questioned, though, because there appeared to be no appreciable difference between the two types of metal in cracking by thermal fatigue. Leading-edge cracks appeared in all samples after about 50 hr.

A report on these tests, and on the effects of aluminizing on bucket life, is being made available through National Aeronautics and Space Administration as TN-D263.

New technical camera, designed in Holland, features a tilting lens holder that can be adjusted without changing the optical setting, and a building-block design that makes it possible to change lens board, bellows and focusing-screen frame as needed. Frame sizes are 4 by 5, 5 by 7 and 8 by 10 in. Favero Nv, Hengelo (O.) Holland, makes the camera, calls it the "Super-Cambo." A data sheet in English is available. —ARG

DUTCH CAMERA is designed for flexibility of use; takes regular or wide-angle bellows.

RESISTS ROUGH HANDLING!

Safeguard your investment in costly originals with durable drafting films of Du Pont MYLAR®

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If you would like samples for testing, we will ask manufacturers of drafting film of "Mylar" to send you a sample. Write E. I. du Pont de Nemours & Co. (Inc.), Film Dept., Room PE-4, Wilmington 98, Delaware.

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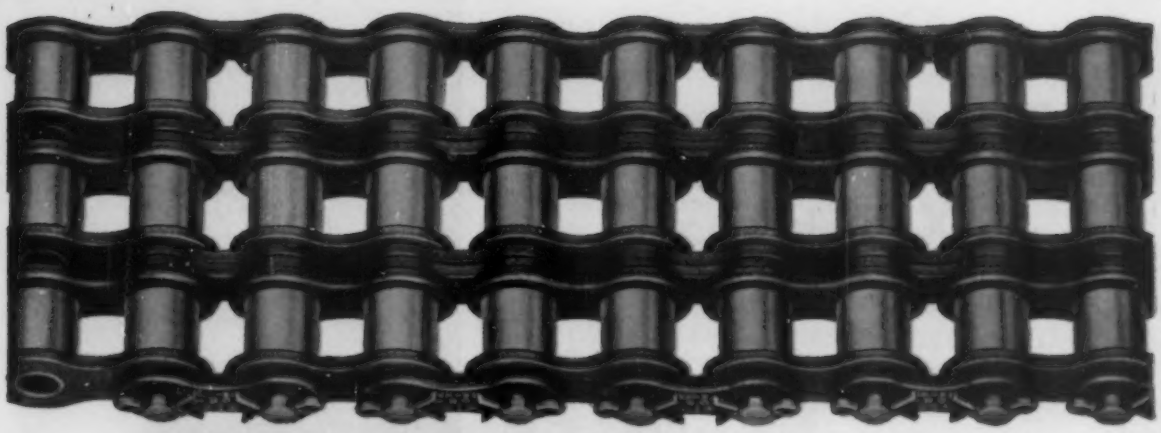
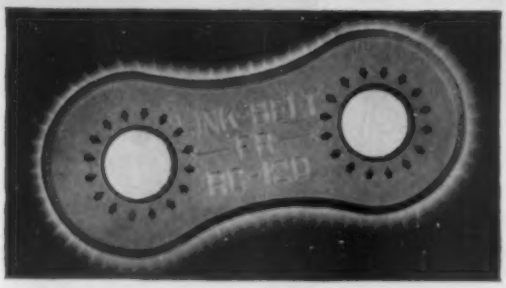
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

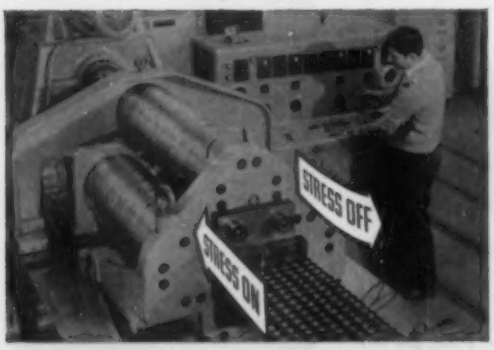
DU PONT **MYLAR®** POLYESTER FILM





Arrows indicate critical areas treated with compressive stresses to improve fatigue resistance.

Fortified against fatigue



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Link-Belt offers special FR® processed roller chain for applications involving repeated high-tensile loads

Jobs too rugged for standard roller chains are taken in stride by Link-Belt FR roller chain. Through its patented FR process, Link-Belt gives *greater dynamic strength* to the larger sizes of chain most likely to encounter severe cyclic loading. FR greatly raises the chain's endurance limit by compressing metal around pitch holes—the critical sidebar areas most vulnerable to fatigue failure.

The FR process results from the same design and metallurgical research that has produced many more "extras", all *standard* in Link-Belt roller chains. They include shot-peened rollers, close heat-treat control, lock-type bushings and others. For further details on Link-Belt roller chains, send for Book 2657.

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ROLLER CHAINS AND SPROCKETS

BOOK 2657 has 154 pages of roller chain data. For your copy, contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your phone book.)

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

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A-X TUBING

Anaconda A-X tubing is a flexible metal connector with annular corrugations designed to handle the types of movement shown at the right while conveying liquids or gases. It is available in stainless steel and other alloys and is generally sold complete with fittings (right, below). Nominal tubing I.D.'s: 5", 6", 8", 10", 12", 14".

Most axial motion applications involve motion in one direction in respect to the installed position. This may result in compression or extension of the tubing. In a few applications an assembly may be subjected to both extension and compression in relation to the installed length – such cases occur when temperature varies both above and below installation temperature. In order to give the best service for each type of application there are three different corrugation standards for each tubing size:

PRE-COMPRESSED. Designed for extension movement. Will allow a small amount of compression.

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Bulletin A-X 97 gives complete details. Call your Anaconda Metal Hose representative for a copy—or for the services of an Anaconda specialist to help you in the design of a special connector to meet your needs. Or send in coupon below.

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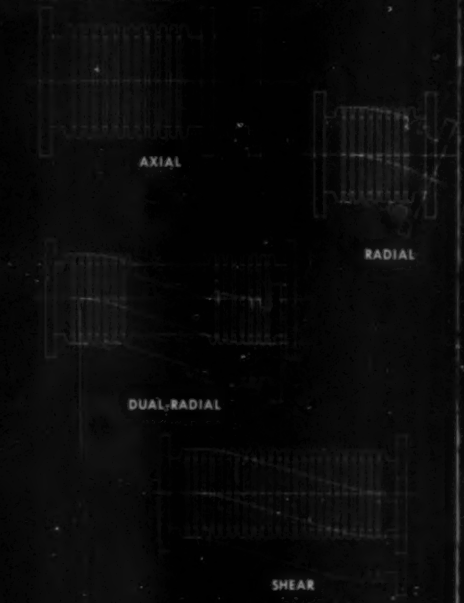
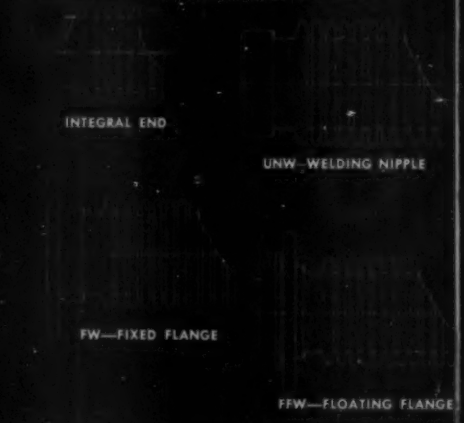
BASIC STANDARD UNIT

TYPES OF MOTION



FITTINGS FOR A-X TUBING—UNBRAIDED



FITTINGS FOR A-X TUBING—BRAIDED

FROM WASHINGTON . . .

Engineering challenge—ways to land spacecraft

Design engineers have been thrown a real challenge. **The Air Force's Air Research and Development Command is scouting for ways to land spacecraft on unexplored terrain.** Secondly, it wants a way to couple orbiting space vehicles.

A $95,000 contract has been given to Cleveland Pneumatic Industries Instrumentation and Control Div to conduct a 12-month study into the matter. Air Force says conventional landing gear such as wheels, skids, skis and floats won't work. So it wants the company to explore various tethering, grappling and receiving methods. Not only must the system provide for safe landings, but also allow for takeoffs.

This is part of the nation's space program that is expected to cost from $12 to 15 billion over the next 10 years. Space Administrator T. Keith Glennan told Congress recently that government spending for space would climb from over $900 million in fiscal 1961 to "more than $1 billion in 1962." And it will edge upward still more each year over the next decade.

Third-generation Polaris submarines proposed

New class of the Polaris submarine is being designed. The first five subs were merely modifications of units under construction (*PE—Feb 23 '59, p 21*). A second generation of submarines, designed especially to handle the Polaris missile, is now under construction. **And Navy wants to jump to the third generation of the fleet ballistic-missile submarine.** Navy won't discuss specific improvements in the new class except to say there will be new weapon-system techniques.

Navy has announced plans to pump an additional $52 million into its Polaris program too. The money, Navy says, is being pulled from other projects. It will be used to hurry along construction of seven of its Polaris-toting nuclear-powered submarines. Each sub carries 16 of the 1200- to 1500-mi solid-fueled missiles. Final tests of the Polaris are now underway.

Air Force juggles strategic defense concepts

A major shift in air-defense strategy has been unveiled by the Air Force. **It wants to trim around $600 million from its 400-mi Bomarc-B program and the SAGE (semiautomatic ground environment) underground-control centers.**

Bomarc is an antiaircraft missile, and SAGE an electronic control system for both manned fighters and antiaircraft missiles. Earlier versions of the Bomarc and above-ground SAGE control centers are not affected by the proposed Air Force cuts, however.

New concept based on better studies is the reason given for wanting to make the shifts. The Air Force's proposals must still be approved by Congress and the Secretary of Defense. But, if adopted, here is where the service would pump the money: **about $100 million would go for 12 more Atlas missiles and launching pads; $25 million would be used to speed development of the solid-fueled Minuteman ICBM; another $150 million, to step up construction of the second and third Ballistic Missile Early Warning (BMEWS) bases at Clear, Alaska, and in northern England.**

About $150 million would go to improve the "Century Series" jet-fighter-interceptor aircraft; and the balance would modernize radar systems and "plug the gaps" in the Distant Early Warning and Pine Tree Early Warning systems that are guarding against attack across the North Pole.

Experience—*the added alloy in* **Allegheny Stainless**

form
Stainless steels can be bent, drawn, and roll-formed by all the standard techniques known in the metalworking industry. In these operations, stainless requires somewhat greater power and harder tools than it takes to work softer materials. But this characteristic stems directly from stainless steel's superior ability to withstand bending and denting in service.
This attractive stainless cocktail set was produced by flow-turning—one of the newer metalworking techniques that have been developed to offer new answers to many design problems. With these improved fabricating techniques, components that formerly called for two or more materials can often be made better or more economically from one solid material that fills all the requirements of design. The techniques of spinning and abrasive wheel polishing offer special design possibilities, as exemplified by the spun dish on page 7. For further information on the degree of forming possible with a specific type of stainless, contact your nearest A-L office.
Stainless Cocktail Set
Stainless Auto Heaters

Sample pages from A-L's new free booklet on design

"Design and Allegheny Stainless" is illustrated page after page with hand-picked examples of good design in the gleaming metal.

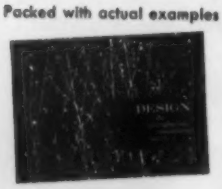
Twenty-four photographs and drawings in full color, twenty-six in dual color and black and white become a showcase of the versatility of stainless.

The examples are presented with text in terms of Function, Shape, Texture and Color. They cover many fields from automotive parts to holloware for the home . . . to open new horizons for the designer.

There is a working outline of types and properties in the many grades of Allegheny Stainless. Some of the new textures illustrated will interest the designer looking for new effects.

Write for your copy of "Design in Allegheny Stainless Steel"—without cost or obligation. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. PE-4.*

Packed with actual examples of good design—and ideas for future applications



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EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

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984

THE ENGINEERING WEEK

AUTOMATED BRAILLE WRITER is a development wholly financed by Systematics Inc, after the need for such equipment was pointed up by Edward Flamm, Integrated Data Processing Systems. Dr. J. Fried of the Jewish Braille Institute of America lent the company a Perkins Brailler and briefed the engineers on peculiarities of Braille code. There are no immediate marketing plans.

Automated Solution Answers Fast-Braille Problem

HERMOS BEACH, CALIF—"Wanted . . . a device working on the punched-tape principle, for reproducing Braille."

A year after that line appeared in PRODUCT ENGINEERING (Dec 29 '58, p 25), such a Braille printer—with tape input and output—was exhibited to agencies of the blind. Edward Flamm of Integrated Data Processing System, NY, originated and coordinated the idea; Systematics, Inc, a manufacturer of data-processing equipment of Hermosa Beach, designed and constructed the prototype equipment.

The problem, as described by Theodore Bruinsma, Systematics president, was this: The visually handicapped have had access to written words since Louis Braille invented his system of communication through raised dots. But the number and variety of books available to the blind has been painfully limited because the quantity of such texts seldom justifies the expense of typesetting. Hence, each copy is individually typed by hand, usually by volunteers on a spare-time basis and may take six months.

Systematics equipment for multiple copies of Braille texts uses the "Flamm Technique." A punched-paper-tape device linked to the standard Perkins Brailler (a 6-key typewriter for embossing Braille symbols) automatically produces an 8-channel coded tape while the original copy of a text is typed. Six of the channels denote Braille symbol positions; the two others signal movements such as paper advance and spacing between lines. A tape reader ties into the Braille typewriter and transmits tape commands to the Brailler for reproduction copies of the original typed page.

The mechanical Perkins Brailler has been motorized and equipped with an automatic carriage and line spacer. Copy reproduction is limited by motor speed, but is said to be faster than original typing. Flamm envisions combining the printer and tape units, and feeding tape directly to a high-speed line printer. With his present system, several Braillers must be attached to a single reader for mass reproductions.

Several other advances are foreseen. One is development of a central library where punched-paper tapes from the more than 2000 Braillers now in existence could be reproduced at high speed, permitting wider distribution of the material. Flamm also suggests possibility of an International Data Processing Center that would translate from language-to-language using Braille, which is a common code. The center would act as a decoder taking Braille-printed literature and, by optical or tape means, present it to the decoder, which through memory storage would translate to the desired language—and back again, optically or electronically, to tape and pages. ■

Rise in Welding Speed Outmodes Standards

BAY CITY, MICH—The sharp upward spurt in resistance-welding speeds achieved during the past five years has completely outdated the speeds recommended in standard reference works, report J. Paul Thorne and Harold Bach, officials of the Resistance Welders Manufacturing Assn. They blame the outmoded speed standards for putting resistance welding in a bad light when compared to other joining methods.

Inasmuch as design considerations and functional and appearance requirements influence the welding speed possible in a specific instance, the more realistic speeds cited by the two men are only a general guide.

Gastight or watertight lap welds between sheets from 0.020 to 0.060 in. thick are now produced at speeds at least 20% and more often 50% higher than the recommended 6 to 15 ft/min. on uncoated and on some coated stocks including Terneplate, Paintlok and Zincgrip, but not on galvanized stock.

In the continuous-current welding process, speeds are 100% higher than those recommended. Indeed, the process does not operate satisfactorily at lower speeds.

Gasoline tanks made from 0.026-in. stock are being welded at speeds 70% over recommended practice.

Roller-spot beads applied at intervals of two to three in. are produced at speeds 50% higher than they were five years ago.

A number of developments are listed by Thorne as contributing to the increased welding speeds: more rugged welder construction with more consistent electrical characteristics; availability of stiffer power supply for welding; improvement in quality and uniformity of alloys; better design of welding machines, incorporating antifriction wheel bearings and improved electrical controls.

Intermittent drive of the seam-welding roll produces better welds on heavier sections and at higher speeds than were common only a few years ago. The technique is especially indicated in the welding of stainless steel,

which requires maintenance of high pressure on the weld point during solidification.

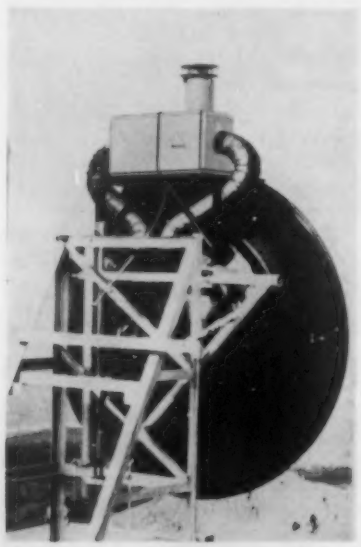
Mash seam welds are used where thickness through the weld must be kept at a minimum. This process, too, has seen great improvements in welding speeds. Where standard references recommend welding of 16- and 18-gage stock at speeds of 8 ft/min., speeds of 40 to 50 ft/min. are being achieved.

In the welding of containers from 5- to 55-gal. capacity, speed increases of 50% or more have been registered in the last five years. In some instances, production rates on containers have jumped to 700/hr from 300/hr less than five years ago.

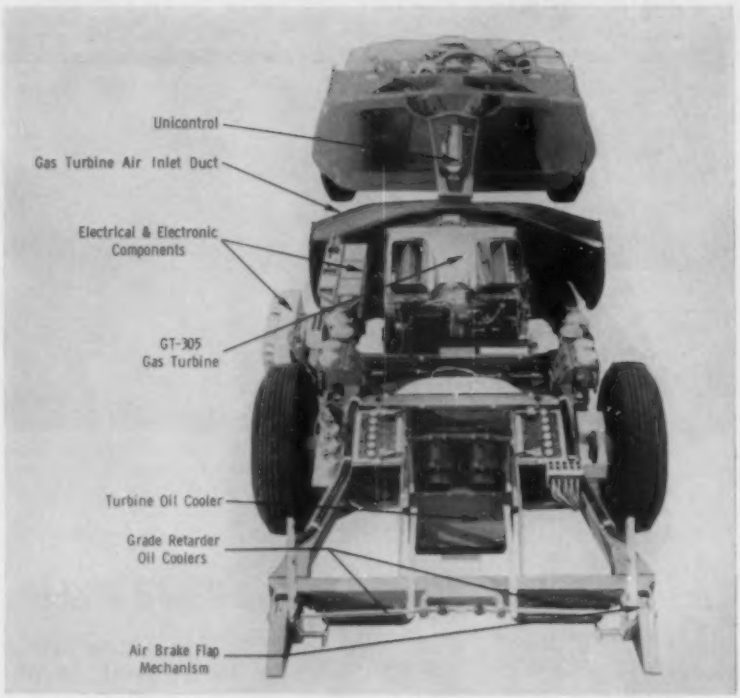
Here, higher speeds have resulted from the development of more precise means for controlling overlap, by more effective cleaning of the edge of the sheet to be welded, and by the design of welding machines that relieve grooving of the electrode wheel.

—Felix Giordano

Mountain Antennas Defrosted



Snorkel-like gas heaters, mounted atop microwave relay antennas, prevent ice formations that might reduce their transmission range. The 10-ft-dia antennas are spaced 50 miles apart along Nevada's snow-swept mountains. Heaters built by Reznor Mfg Co function automatically to blow 130-F air across the antenna. Snorkel provides air intake for burners and vents for exhaust gases. Heaters produce 60,000 btu per hour and operate on 115-volt, 60-cycle line current.



GM FIREBIRD III incorporates advance design characteristics in its chassis as well as powerplant and external appearance. Front compartment is used primarily for auxiliary engine and all accessories. Rear compartment houses a gas turbine engine with integral transmission, rear axle and retarder. Electrical relays and electronic equipment for communications and control are located to left of engine. Single backbone section of frame through passenger compartment accommodates car control mechanism and space for hydraulic lines and electrical wires between front and rear.

What's ahead in Automotive Engineering

McGraw-Hill's Detroit News Bureau sees no major revolution in car design during the 1960s.

- **Present engines may be replaced, but not with gas turbines. Stirling engine is getting the most attention.**
- **Transmission and axle design will be replaced with the transaxle on some 1962 cars.**
- **Unorthodox suspension awaits something better than air.**
- **Central hydraulic systems are in advance state of development.**

Biggest change in the decade will be the package, not the components—that sums up the situation.

DETROIT—Most automotive engineers doubt that the gas turbine will ever replace the piston engine in US passenger cars. This and other expectations about the future of American automobile design were gleaned from sampling for PRODUCT ENGINEERING of the opinions of leading automotive engineers and executives here.

Maurice Olley, dean of US automotive engineers, was asked: What's ahead in automotive engines? "The Wankel or the Stirling," he replied. "Gas turbines are too extravagant. And our familiar high-compression engine using high-test gasoline may be just about dead. If this were 1900—if we were starting fresh—some enterprising mechanic would stick a Stirling engine in a vehicle. That's the attitude we need today!"

Detroit suspicion of the rotary engine called the Wankel is well documented (*PE*—Dec 28 '59, p 17). Joseph B Bidwell, head of engineering mechanics for GM, noted that a car

engine must be efficient at output requirements ranging from 20 to 120 horsepower at the wheels, and went ahead to tick off problems and advantages of other esoteric powerplants:

• Gas turbines have bad part-load fuel economy. To lick this, you lose simplicity, size and weight.

• The free-piston engine has a mechanical complexity that does not suit it to small sizes. A fuel-injection system is required and high temperatures and pressures must be controlled.

• The Stirling engine is promising. It could someday be better than the piston engine at its best. Complete combustion gives a clean exhaust, and smog problems might grow to override other engine design considerations.

• It's hard to visualize carrying an atomic reactor around in a car.

• Fuel cells may someday be developed that will operate with conventional air and hydrocarbon fuels. But how do you use the electricity in the car? Electric drive motors and controllers have good characteristics if you forget their size, weight and expense.

• Steam is a province left only to a few cranks. A new powerplant won't be adopted just because it's different.

Engineers feel that the piston engine has a great future. Current auto industry research on these is given 10 manhours to every one devoted to alternate powerplants, and consensus is that American designs, at least, will follow the route of large displacement coupled to a low numerical axle ratio. This is for optimum performance, economy and durability.

Bidwell feels that the size and weight problem must be approached through new materials. Extension of aircooling beyond the Corvair he regards as problematical. Liquid coolants are useful for other purposes, such as removing heat from the automatic transmission and warming the passengers.

Some experts feel that fuel injection has a future in the conventional passenger car. Ford's A. F. Cleveland, who heads reciprocating-engine development for that company, wonders why someone doesn't design an engine around a fuel-injection system, instead of just tacking it on as an accessory. And Bidwell notes that fuel-injection costs are going down while carburetors, due to complexity, are becoming ever more expensive. The two could meet, at least in high performance, luxury cars. Pressure metering versus vacuum is about the only distinction nowadays.

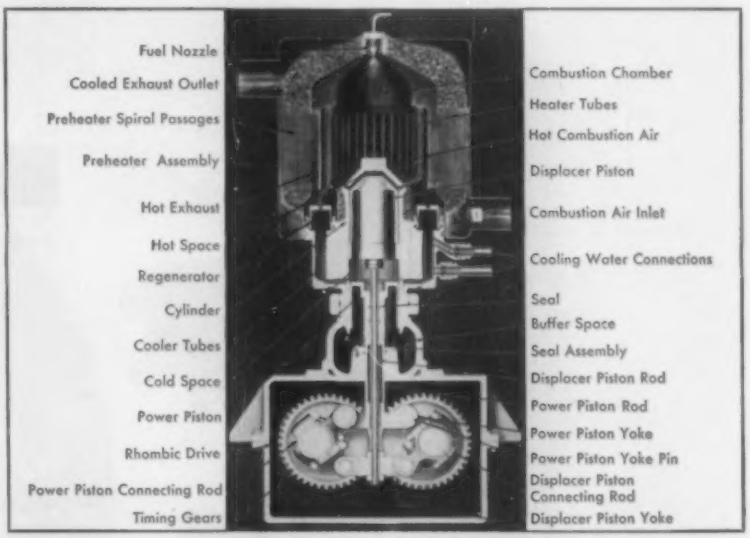
Current goals for automatic transmissions are less loss of power and greater simplification—two normally incompatible ideals. This would seem to rule out an idea advanced by one company to attach two torque converters face to face along the axis of the rear axle and thus eliminate the differential.

Hydrostatic transmissions at each wheel have been discussed, but if a car is to have 100 hp available at speeds ranging from 20 to 100 mph, a 500 hp power source and a pump of similar size would be required. Line losses drop the over-all efficiencies below a conventional drivetrain.

The much touted transaxle, which places the transmission astride the differential either at the front or the rear is now programed for certain 1962 models. Olley feels that lethargy in this development is due to cost and manufacturing worries over the necessary swing axle; engineers close to production problems estimate the price increment to be at least $50 per car.

About the only advantage gained with a transaxle on a front-engined, rear-drive car is in cutting down size of the driveshaft tunnel. Engineers would rather see the floor raised; it's simpler, but of course the stylists would not permit this. Olley sees no problem in creating a front-wheel-drive car, provided the engine is de-

continued on page 20



STIRLING ENGINE is an external combustion type. Neither fuel nor products of combustion enter the engine cylinder. The heat enters the engine head through the metal walls of a heat exchanger, and is transferred to a working fluid (air, helium or hydrogen) completely sealed within the spaces of the engine. Expansion and compression of this fluid, brought about by rapid cooling and heating, moves the engine pistons—any heat source that provides high enough temperatures will do.

There are 5 major elements: engine heater, regenerator, engine cooler, displacer piston that controls the movement of the working fluid, and the work or power piston that compresses and expands volume of the fluid.

Cycle is as follows. In the first position, power piston is at bottom of the cylinder and displacer is about mid-stroke. Part of the working fluid is in the cold space between the pistons. First process—isothermal compression—is through movement of the work and displacer pistons upward, reducing the volume of fluid in the engine and forcing all the fluid into the cold space. Next, the heating process is accomplished by moving displacer piston downward, without movement of the power piston. This forces the working fluid out of the cylinder, upward through the cooler, regenerator, and heater into the hot space above the displacer piston. Isothermal expansion occurs, and the work piston moves downward to its initial position. Cycle is completed by movement of the displacer upward to its original position—forcing part of the fluid to return to the cold space between the pistons. Power reaches timing gears via the rhombic drive.

Precision in Small Packages...

Series "SM"

Series "V3"

Series "T8"

All basic switches shown approximately actual size.

Series "1SX"

Series "Z"

The actuators which form the background on this page are only a few of the hundreds available for these MICRO SWITCH Basic Switches. MICRO SWITCH engineers can help you choose not only the right switch, but also the right actuation method for your particular application.

H HONEYWELL

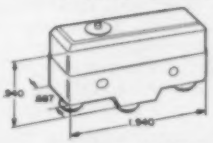
MICRO SWITCH Precision Switches

Start with the Best in Basic Switches!

When design dimensions get you thinking small, don't let that carry over into the consideration of switch quality. MICRO SWITCH Basic Switches consistently save you space, but never at a sacrifice in precision and reliability. Start with the best and be sure of the exclusive MICRO SWITCH spring and anchor designs; get the protection of materials testing "by the inch" and operational tests that exactly duplicate the conditions under which your switch must operate. You also get more years of experience for design consultation because MICRO SWITCH pioneered the subminiature switch industry. Variations on these basic switches number in the thousands, including those designed to meet military standards. You'll find it easy to select exactly the right answer with the prompt help of the nearby MICRO SWITCH branch office listed in the Yellow Pages.

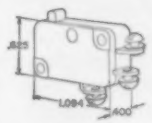
This 72-foot control panel monitors tests where your operating methods and environmental conditions can be duplicated exactly for millions of switch operations.

TYPE "Z" AND "A" BASIC SWITCHES



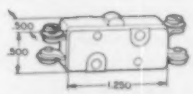
These are the original basic switches that were the pioneers in small snap-action precision switches. Today hundreds of variations serve with precision and reliability in thousands of jobs throughout industry.

TYPE "V3" BASIC SWITCHES



Miniature size with very high electrical capacity. The "V3" Series includes many different types of terminals, contact arrangements, and materials for a wide range of operating temperatures.

TYPE "TB" BASIC SWITCHES



These are small, two-circuit double-break switches for controlling two isolated circuits. They save space and weight, allow flexibility and simplicity of circuit design.

TYPE "SM" BASIC SWITCHES

"SM" Subminiature Switches bring MICRO SWITCH precision to applications where space and weight limitations are critical. Many different "SM" types are available to meet varying requirements for high-temperature applications and long operating life. Special gold or bifurcated contacts are also available.

TYPE "1SX" BASIC SWITCH

This sub-subminiature is the smallest single-pole double-throw snap-action switch available. Despite its tiny size it combines long operating life with ample electrical capacity. This is a perfect example of MICRO SWITCH precision in space-saving sub-subminiature size.

Write for New Catalogs 62 and 63 on Small Basic Switches.

MICRO SWITCH . . . FREEPORT, ILLINOIS
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H HONEYWELL **Honeywell**
MICRO SWITCH Precision Switches

continued from page 17
signed specifically for it. He visualizes it sitting transversely on top of the differential.

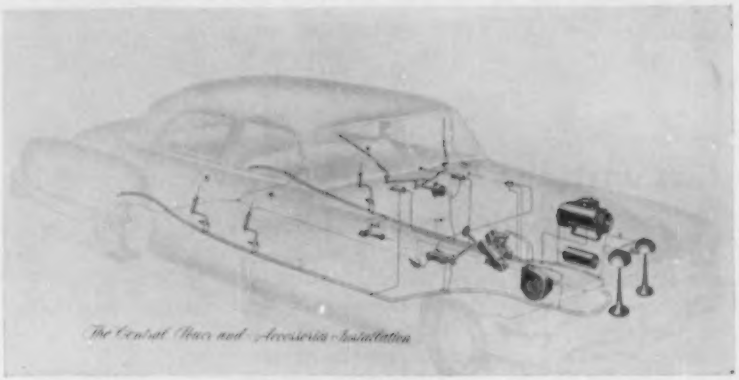
ALL-HYDRAULIC ACCESSORIES

Ford is known to be working on front-engine, front-wheel drive, especially for its forthcoming 95-in.-wheelbase "Compact Compact." Chevrolet, conversely, is pursuing rear-engine designs for its standard-size model.

Suspension design appears stalemated. The much heralded air-suspension system is now sold only by Cadillac. It is freely admitted that air did not offer advantages commensurate with its cost. Two things, though, could renew interest in unorthodox suspension: one would be legislation requiring a leveling feature on vehicles to prevent headlight glare; the other would be the central hydraulic system.

This system is simply a pump and accumulator which operates a number of accessories. It is known to be in an advanced state of development at both Ford and the Autolite Company. A committee at the recent national SAE meeting gave it a further push when it set up tentative specifications for both petroleum-based and synthetic fluids, thus allowing realistic road tests.

Engineers, such as Ford's Thomas H. Risk, envision hydraulic operation of brakes, steering gear, windshield wipers, windows, seats, convertible tops, starter, fuel pump, automatic transmission and suspension leveling. Existing accumulator designs allow 70 average brake stops with one complete charging. With the engine running, of course, the accumulator is constantly charged.



CENTRAL HYDRAULIC SYSTEM can relieve presently overloaded electrical system, the reason why Autolite proposes this design. Major problem was to overcome leakage. Autolite claims this is solved by using smooth, chrome-plated piston rods and smooth O-rings. System is also claimed fail-safe. Closed-center valves keep fluid under pressure until opened.

A source of high hydraulic pressure opens up new vistas in brake design. "Full-power" hydraulic brakes operate when the pressure is released, rather than applied, as in a conventional master cylinder. This results in very fast reaction time without the spongy feel of air brakes. Vapor lock would be unknown because of the high pressures, and aircraft-type, nonskid brake designs could be utilized.

Biggest change in the decade ahead will come in the package rather than its components. This opinion is pinpointed by George W. Walker, Ford's vp in charge of styling, who predicts a "substantial need in the years ahead for highly specialized vehicles to meet special kinds of individual family requirements." He feels there is growing evidence that one car can't serve every purpose.–Don MacDonald

Survey Finds Consumers Eager to Buy Durable Goods

Ann Arbor, Mich—Consumers have been much more inclined to buy goods and services since the steel strike, but demand is still below 1955-56, according to the Univ of Michigan Survey Research Center. The center, which has been making surveys of consumer attitudes for the past 16 years, says that the present mood of the consumer will provide a positive stimulus to the American economy, but not a boom in consumer spending as predicted by some economists.

3000 FAMILIES INTERVIEWED

The center's findings are based on interviews with 3000 families across the nation, during January and February. Previously financed by the Federal Reserve Board, the project this year was financed by private industry and the Ford Foundation.

The proportion who think "it's a good time to buy" automobiles and other durable goods is much higher now than a year ago, the center said. Intentions to buy new cars are now about 20% above a year ago, but only a little ahead of June or November 1959. The center also notes that consumer attitudes toward compact cars remain favorable.

MORE CASH AVAILABLE

Three out of four Americans believe "good times" will prevail in the next 12 months. Only 7% foresee bad times; 11% are uncertain; 5% see both good and bad trends operating; and 2% have no opinion.

A general improvement in ability to buy has accompanied the development of more favorable attitudes toward buying, the center also found. The proportion of upper-income families has increased, and the distribution of liquid assets (cash, government bonds, etc) is more favorable than a few years ago. ■

Soviets Unhappy About Lag in Plastics Technology

Moscow—Three top-ranking Soviet scientists are trying to light a fire under chemical plants that fail to make use of technological advantages in the polymer field. V. Kargin, V. Smirnov, and M. Rokhlin, members of the USSR Academy of Sciences warned the government against any tendency to over-emphasize development of new polymer materials when the industry at present is not making the most of existing technology.

Polyvinyl chloride is cited as an example, showing that in other countries PVC can be shockproof, transparent and workable in many ways, including pressure casting. "In Russia," the scientists say, "the quality remains the same as it was 10 years ago. It is not transparent; has low workability; ages rapidly; does not meet the requirements of modern elec-

trical engineering; and, in fact, is most unsuitable for highly productive methods of manufacture."

The critics emphasize that low-quality PVC is not the fault of poor scientists or inadequate facilities. It is more a factor of poor planning and lack of updating on the part of industry. They place the blame on bureaucracy: "Evidently it is the result of those same purely departmental differences that used to arise when we still had the industrial ministries."

The scientists had similar criticism for other fields: cellulose and cellulose fibers; wood plastics; pure chemicals. ■

More Polypropylene Parts Coming

CHIPPEWA FALLS, WIS—With capacity for polypropylene resin (*PE*—Sep 29 '58, p 36) slated to top 100 million lb this year, more and more companies are preparing to offer stock parts in this material—handles, knobs, bushing, tubing and the like. Most of these are in the one-customer or market-test stage right now, but they are moving toward the stock shelves fast.

Recently, for instance, Chippewa Plastics (Div of Rexall Drug) announced it was producing translucent polypropylene for a special industrial application. This one is still under test, but the company is already laying plans for making it a standard production item.

As a result of tests conducted in the past few months, some of the more optimistic producers of the basic resin expect it will eventually replace linear (rigid) polyethylene in application ranging from wire coatings to truck wheels. ■

New Nickel-coating Process Produces Low-cost Dies

PHILADELPHIA—A vapor-coating process for depositing nickel on any shape has been developed by The Budd Co. Called Carbonyl Nickel Process, it is currently being used to produce low-cost dies for forming sheet-metal parts. Budd claims that high rates of deposition, and ability to deposit on any shape gives this process cost advantages over conventional deposition of nickel by electroplating or by electroless methods such as the Kanigen Process.

Here's how it works: A wood or plaster model of the desired shape is made and sprayed with a low-melting eutectic such as an epoxy resin. The model is removed, the eutectic pattern is placed in a coating chamber, and heat is applied to one side of the pattern while carbonyl gas containing nickel is sprayed on the other side. The gas side of the chamber is completely sealed. When removed from the chamber and the eutectic stripped out, the heavy nickel shell becomes a low-cost forming or drawing die, foundry pattern, or permanent mold.

The nickel shell, says Budd, has excellent resistance to abrasion and to mechanical shock normally met in forming tools. Reproducible dimensional accuracy is reported better than ±0.005 in. Size of the die formed is limited only by the dimensions of the reacting chamber; largest to date is 60 by 100 in.

Budd emphasizes that this is not a do-it-yourself process. The carbonyl gas is toxic in concentrations as low as one part per billion, is highly unstable and will explode if mixed with oxygen or air. ■

Nuclear Power Units To Get Bigger

NEW YORK—Latest development in a series of nuclear auxiliary power units for space is a 30,000-watt unit now being designed by Atomic International.

However, it's not ready for flight at the present time. In fact, NASA is only now negotiating a construction contract to get the project under way. The space agency expects that the unit will be ready for flight in about 5 years, at which time the spacecraft to use it should also have been tested and available.

This newest unit, designated SNAP-8, will use liquid mercury as the heat-exchange medium, with an estimated weight of approximately 1500 lb. Aerojet-General will likely be the builder.

NICKET-SHELL DIE (left) and rough casting of punch (right) used to back up the shell. Thin dies use an epoxy to fill spaces between die and punch before insertion into the press. Present shells can be made 0.050 to 0.400 in. thick, and are formed in 8-10 hr for the smaller thicknesses to 36-40 hr for the larger. Future plans call for plating speeds of 0.015 to 0.020 in./hr.

CARBONYL-GAS MANIFOLD LEADS are positioned over low-melting eutectic patterns to ensure equal deposition of nickel. Gastight lid is put in place and chamber purged before nickel-containing gas is pumped into manifold. Lower part of chamber is electrically heated. Highly toxic gas is a safety and health hazard, and requires careful handling. As indicated, gas masks are a requirement.

HERCULES

Plastics Hi-Lites

Vol. II, No. 1

New plastics are the big story in today's modern appliances

INSIDE OR OUT, PRO-FAX® APPLIES—a real performer, Pro-fax! It's built to stand up to the most rugged use challenges whether they be indoors or outside. As a result, this newest of plastics—Hercules polypropylene—has been finding increasing use in appliances that call for the finest in appearance and performance. Tough, rigid, heat-resistant, hard to stain, Pro-fax is richly colorful and the lightest plastic ever.

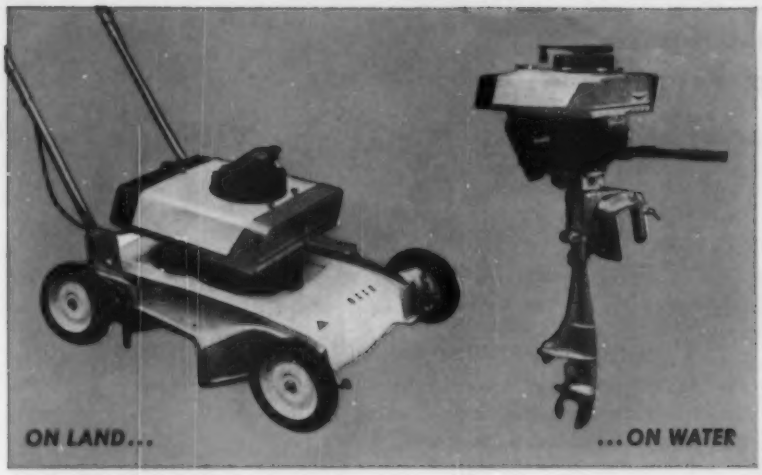
Pro-fax has opened up a whole area of new thermoplastic usage. Now designers have at their command a structural material that can often be used to replace more costly raw materials. Easy to mold, Pro-fax can be used to produce precision-formed units at low cost. It's little wonder that so many of the nation's leading appliance manufacturers are turning to Pro-fax to help solve production problems, and to give added values to their products.

A TRIPLE PLAY BY PRO-FAX

This Triple Duty Filter Dispenser, an exclusive feature found in all Philco-Bendix "Automagic" washers, is another example of the advanced engineering made possible by the proper use of such new plastics as Pro-fax polypropylene. Exploded view (left) shows the six injection-molded parts which make up the assembly of this compact, highly functional unit. Removable cap and cup shown at top are polyethylene. The remainder of the unit consists of four precision-molded Pro-fax parts which are ingeniously joined to form the body of the dispenser filter. The dispenser lid is permanently joined to the upper half of the body by spin-welding, while the lower half is attached by self-tapping screws. The removable filter trap (at bottom) has a molded bayonet-type catch, with an insert-molded metal mesh filter. Pro-fax was selected for this demanding assignment because of its outstanding resistance to detergents and chemicals, and its ability to withstand prolonged exposures to high temperatures. Lightweight; a handsome, colorful finish; and resistance to breakage are other features of the new unit. And of course the producer enjoyed all the important processing bonuses provided by Pro-fax, including more parts per pound, and dimensionally stable, precision fitting components.

Instantly accessible when the washer is open, Philco's Triple Duty Dispenser serves three important functions in the washing cycle. The entire tub of water is filtered six times a minute to remove all traces of lint. It provides automatic detergent dispensing at any preselected water level, insuring even dispersion; and it automatically dispenses clothes conditioner at the proper time to assure a softer, cleaner wash.

Molded by Seneca Plastics Company, Cambridge, Ohio.



DOUBLE PLAY BY ACCO

The new Acco "Outboard Mower" is not only an industry first, but one of the first big new merchandising ideas of many a year. It's a power mower with a motor that can be removed and attached to a propeller unit to make a powerful outboard motor. The conversion can be effected in minutes, and on land or water the motor is protected at all times by a colorful, durable housing molded with Pro-fax. Pro-fax proved the only plastic with all the requirements demanded by this new concept in dual-purpose equipment: lightweight, rigidity, resistance to heat, chemicals and staining, plus a lustrous surface finish that bespeaks quality merchandise.

Molded by Research Plastics, Inc., Jersey Shore, Penna.

A HIT BY REGINA

This attractive, low-cost plastic accessory is certain to be a hit with homemakers who own a Regina Polisher-Scrubber. Waxing is no longer a chore with this new automatic dispenser unit. Fingertip control assures uniform distribution of wax, avoiding waste and yielding professional results without splashing or stooping. For the ultimate in appearance and performance in this new appliance accessory, Regina selected Pro-fax. In addition to providing lightweight strength in a handsomely styled unit with a colorful, stain-proof finish, Pro-fax supplies the excellent sealing qualities needed for a leak-proof seal, plus resistance to wax solvents such as turpentine.

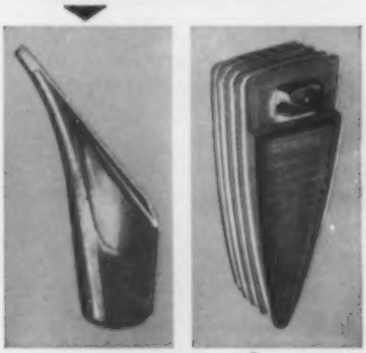
The new Pro-fax pump unit is easily attached to the Regina Polisher-Scrubber handle. When not in use, it will not hamper normal operation.

Pump unit molded by Ideal Plastics Division, Ideal Toy Corporation, Long Island, New York.

Design Hi-lites

The dramatic change-over by producers of light-duty liquid detergents to blow-molded plastic bottles has focused new attention on a long-established processing technique. Blow-molding is one of the oldest of plastic arts, and designers have long been intrigued by the intricate shapes and unusual forms which can be achieved by this method. Until recently, however, materials adaptable to blow-molding lacked the structural and functional characteristics required to yield rigid structures suited to a wide range of uses. The advent of such new plastic materials as Hi-fax, high-density polyethylene, has changed this picture to the point where blow-molding has now become the fastest growing sector of our industry.

Permitting the use of undercuts, blow-molding can achieve intricate shapes impossible by other methods. Modern version of classic vase in design below could serve as watering can, condiment bottle, or medicinal container. Sketches by Sundberg-Ferar.



Blow-molded Hi-fax containers can be designed with a "bellows" action in packages that serve as pumps or dispensers. Design shown above is for a household deodorant or insect spray container.

The sketches shown here are but two of the many exciting and different product ideas shown in a new Hercules film-strip, "Something New in Packaging." If you'd like to see this up-to-date report on a new industry and the materials which serve it, write or call us. It will take only minutes of your time, may put your new products years ahead.

CP60-3

HERCULES POWDER COMPANY
INCORPORATED
900 Market Street, Wilmington 99, Delaware

THREE NEW MATERIALS FOR THE PLASTIC INDUSTRY

HI-FAX® HIGH-DENSITY POLYETHYLENE • PRO-FAX® POLYPROPYLENE • PENTON® CHLORINATED POLYETHER

HERCULES

POINTS OF VIEW

THE QUESTION: *Should Young*

E H Heinemann
Vice-president, engineering
Combat Aircraft Systems
Douglas Aircraft Co

"It's largely a matter of aptitude and interest . . .

The term 'engineer' has, in recent years, broadened its meaning to include those in many highly technical, but unmechanical fields: mathematics, materials, computing, and chemical engineering as well as others where board experience is not very important. On the other hand, engineering in the mechanical fields: aircraft, missiles, automotive, structural, and electronics design is such that a high degree of geometric visualization is very desirable and board experience is therefore most helpful.

"If an engineer has a natural aptitude for design and his interests are to do creative engineering, he will probably not have to be urged to have board experience, as he will find it necessary to use this medium to express himself. Even if he does not have this creativeness, but intends to do engineering of a developmental nature dealing with mechanical devices, ultimately working into management, it will certainly be helpful to start out with some board experience in order to have a better understanding of his chosen field. It is interesting to observe that most of those who have risen to the top in the field of engineering have had early board experience. From personal experience I know that the famous designers in the aircraft industry such as Douglas, Grumman, McDonnell, and Northrop, to mention but a few, have had this experience. Of the 33 years I have spent in aircraft engineering the first 10 were spent with a pencil and drafting machine in hand."

"A qualified yes . . .

Board experience is valuable to the majority of young engineers and to the companies for which they work. However, it should not be a hard-and-fast rule that all young engineers start there. If through some past experience or advanced degree work, the engineer is sure that he wants analytical, test or devlopment work, and the company can train him in a somewhat advanced starting position in this type of work, board work would be a waste of time for both parties.

"I do not want to sell board work short, but in most engineering colleges, design has become an almost routine drafting concept, and the student is bored with spending any further time working on such dull assignments. True, design can be stimulating, and the ability to communicate an idea through a comprehensive design is much more practical than long-winded verbiage.

"Therefore, depending upon what immediate and future plans the student and company have for the individual, some engineers should start on the board and some should not. A good background of design, and not routine tracing, lettering and detailing, could be useful to almost any starting engineer."

Richard L Auten
Engineering personnel supervisor
Sikorsky Aircraft Div
United Aircraft Corp

Engineers Be Started "On the Board"?

C F Hammer
Vice-president, engineering,
Air Brake Div
Westinghouse Air Brake Co

"Yes . . .

Communication among individuals is necessary to ensure the existence of any society of peoples. Communication involves the interchange of information by verbal or written means between two or more individuals through a language known to the individuals. Engineers communicate through the medium of drawings.

"Young engineers are prepared through educational experiences in engineering school to utilize the medium of engineering drawings to varying degrees of proficiency. Practically all areas of engineering activity in which graduate engineers participate require some additional training in drawing technology over that obtained in engineering school. Young engineers entering the fields of product design, development, manufacture, or sales must have the ability to understand detail drawings with a degree of competency that is usually more advanced and specific than that which the engineer receives in a general engineering curriculum while attending school.

"It is our feeling, therefore, that the young engineer entering the employ of a manufacturing organization should be cognizant of this fact and that his drawing education be continued during his initial work assignments. This does not mean, however, that the additional training can be accomplished only by routine, monotonous 'on the board' assignments or that this training must be limited to the confines of a drafting room. Basically the young engineer should be made to realize that in order for him to do a competent job as an individual or as a supervisor of others, he must understand completely the language of his profession and take the necessary steps to fulfill this obligation."

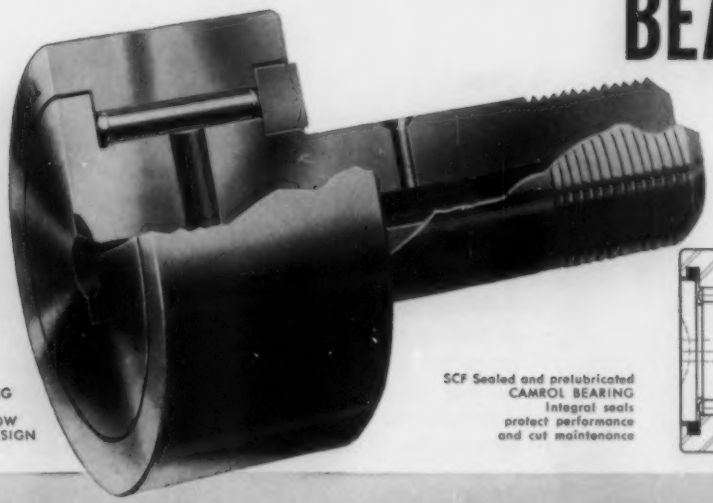
Wallace Herdlein
Executive vice-president
The R C Mahon Co

"Yes, they most certainly should . . .

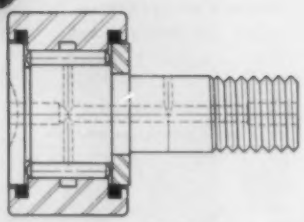
because it's the place where the young engineering-school graduate begins his basic, practical education for an engineering career. It's the place where young engineers gain down-to-earth experiences and background; where they learn to be good, practical designers; where they discover the other man's angles; where they learn about materials. It's a spot where they have the opportunity to follow jobs through the shop to learn what happens to their specifications, and the alternatives for correction.

"The biggest part of engineering is creating through design, and shaping up the end product through wide knowledge and experience with materials. The board provides the basic steppingstone for a young engineer to branch out; to use his imagination; to visualize quickly, within a framework of costs, what is needed from a practical standpoint to create the end product."

McGILL® CAMROL® BEARINGS



CF CAMROL BEARING
CUT AWAY TO SHOW INTEGRAL STUD DESIGN



SCF Sealed and prelubricated CAMROL BEARING
Integral seals protect performance and cut maintenance

SIMPLIFY DESIGN and ASSEMBLY

Stock sizes eliminate the cost of procuring and assembling improvised unit components

You can simplify design and cut cost with CAMROL precision anti-friction cam followers—built for the job. Complete units, with established performance ratings are available from stock in standard roller diameters from ½″ to 4″. Capacities to 20,480 lbs. at 100 R.P.M.

Precision anti-friction bearing accuracy

Precision construction, including concentricity of stud to outer race OD, provides accurate alignment of machine members.

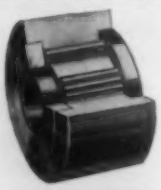
High load capacity in limited space

A full complement of race width rollers provides maximum capacity and ability to withstand heavy intermittent shock loading. The extra heavy outer ring and specially heat treated stud add durability and insures dependability of machine operation. Bolt mounted ball bearings crack under equivalent loads and plain bearings require constant oil lubrication.

Integral seals retain lubrication —keep dirt out

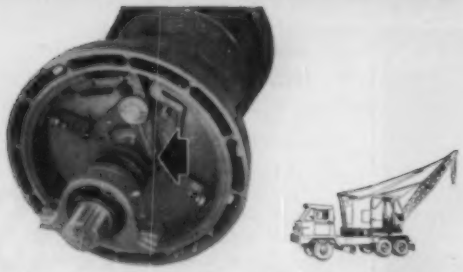
SCF Sealed CAMROL bearings are interchangeable dimensionally with standard CAMROL bearings. They are pre-lubricated and have a ferrous oxide finish to resist corrosion. Effective sealing against contamination reduces machine maintenance.

Camrol CYR series



In the CYR Series, an inner race replaces the stud for yoke or shaft mounting. Standard and sealed CYR bearings are available in the same stock sizes as CF and SCF Series.

SEND FOR McGILL BEARING CATALOG NO. 52-A. for complete data on McGill CAMROL, GUIDEROL, MULTIROL and CAGEROL bearings.



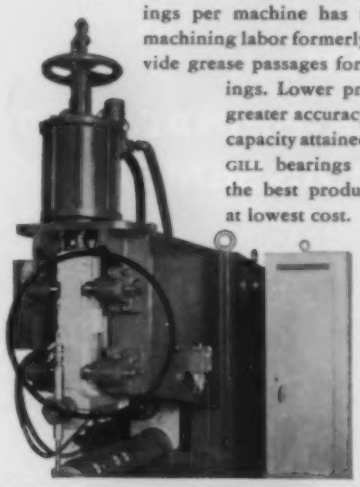
SCHIELD BANTAM UTILIZES CF BEARING ADVANTAGES IN VARIETY OF APPLICATIONS.

The Schield Bantam Company has applied CF bearings in internal clutch band operating arms, turn controls, swing and travel shaft clutch cones, engagement controls and speed shift collars. The photo above shows how CF-1 bearings are applied to Drum Clutches in Schield Bantam Series 350 cranes and shovels.

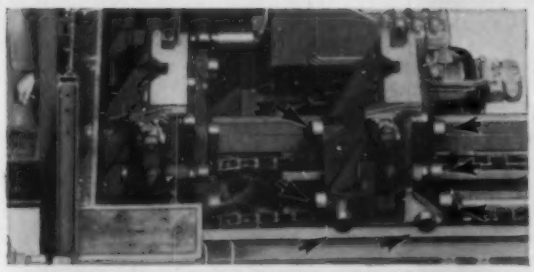
This company replaced bronze collars and yokes and reports cost savings through the use of CAMROL bearings. In addition they have increased capacity and have experienced improvement in length of life and maintenance factors. This has added to the over-all efficiency and dependability in heavy equipment where "down-time" is extremely expensive.

ACRO WELDER REDUCES PRODUCTION COSTS, IMPROVES ACCURACY WITH SCF BEARINGS

SEALED CAMROL bearings are used to accurately locate and guide the welding ram in spot welders made by ACRO WELDER MFG. CO. The user reports that the use of 12 prelubricated CAMROL bearings per machine has saved hours of machining labor formerly needed to provide grease passages for unsealed bearings. Lower production costs, greater accuracy and high load capacity attained with these McGILL bearings help to assure the best product performance at lowest cost.

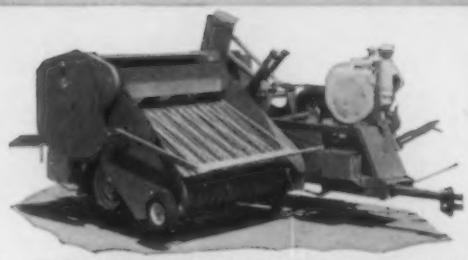


— insure precision performance in cam follower, track and guide roller applications



BUHR MACHINE TOOL CUTS FRICTION TO REDUCE HORSEPOWER WITH SEALED CAMROL BEARINGS

Production parts are drilled, milled, bored and tapped in automated systems engineered and built by the BUHR MACHINE TOOL COMPANY. The moving fixtures which hold parts being machined are guided and carried on McGill sealed CAMROL bearings as shown in the close-up above. By reducing starting and running friction to an absolute minimum, the CAMROL bearings have made horsepower requirement reductions possible in these systems. Ample load capacity, high resistance to shock loads and integral seals which retain lubricant and keep out contamination have held maintenance down. 8 SCF-3 CAMROL bearings guide and support each fixture.



J. I. CASE USES SCF AND SCYR CAMROL BEARINGS IN HAY BALER

The bale compressing plunger of the J. I. Case Model 177 Heavy Duty Hay Baler rolls on CF-2¼-S CAMROL Bearings and CYR-1¾-S Bearings guide the plunger.

Anti-friction bearing dependability and trouble-free performance are essential in this type of field equipment where bearing failure may result in loss of valuable harvesting time.

Integral bearing seals in these CAMROL bearings, keep relubrication requirements low and protect internal bearing components from field dirt, dust and moisture.

In addition to accurate, dependable action with minimum friction, high quality McGill CAMROL bearings offer savings on production and assembly.

engineered electrical products

McGILL®

precision needle roller bearings

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Division
201 N. Lafayette Street, Valparaiso, Indiana

ANCHOR® .... THE PLEDGE OF PERFORMANCE

NOW...

SUPER-SPIRAL HYDRAULIC HOSE ASSEMBLIES

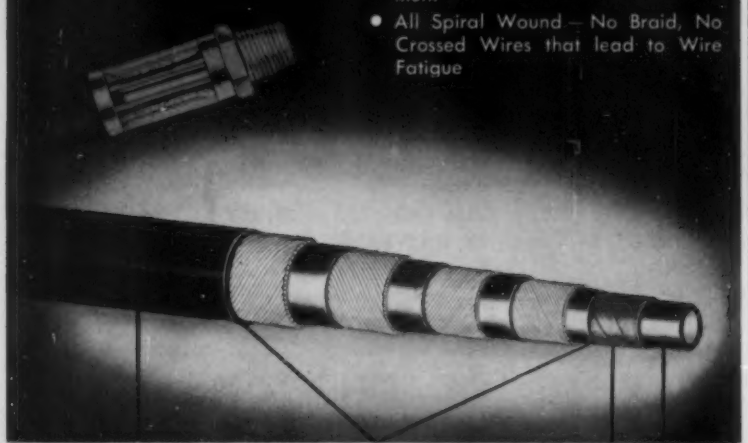
for V.H.P. VERY HIGH PRESSURE

The principal deterrent to the use of higher pressures in hydraulic equipment, with the greater power and versatility that could be provided, has been the lack of a hydraulic hose capable of withstanding these higher pressures.

Now, since the introduction of Anchor's "Super-Spiral" hose assemblies, these limitations which have hampered the hydraulic design engineer, have been eliminated.

Anchor Super-Spiral is available in assemblies with pressed-on threaded or "O" Ring Flanged Head couplings.

- 4 or 6 plies of Spiral Wound Wire Reinforcement
- Maximum Working Pressures from 12,500 PSI (3/16" I.D. — 6 Ply) to 2000 PSI (2" I.D. — 4 Ply)
- Heavy Wire, .022" Dia. Reinforcement
- All Spiral Wound — No Braid, No Crossed Wires that lead to Wire Fatigue



OIL AND WEATHER RESISTANT SYNTHETIC RUBBER COVER

4 or 6 PLIES OF SPIRAL WRAPPED HEAVY WIRE (.022" DIA.)

PLIES OF WOVEN FABRIC

OIL RESISTANT NEOPRENE INNER TUBE

Andy Anchor says:

"The Anchor representative is a specialist in fluid power transmission who is always available for consultation on any of your problems."

ANCHOR COUPLING CO. INC.

317 North Fourth St., Libertyville, Ill.
Branch Plants: Dallas, Tex., Plymouth, Mich.

READER TO EDITOR

Wrong Shear

To the Editor:

Your "8 Steps to Better Engineering Writing" impressed me to a point where I ordered about a dozen and a half reprints. These have been distributed to our engineers.

On the last prints that came in, I noticed you had added "The 9th Step to Better Engineering Writing." I was a little surprised not to find one more comment on your "Step 8." In your "typed copy" you refer to the "shear weight of a double-spaced report;" we have shear stresses and we also have shears to cut out paper with but not "shear" weight. Are you testing our alertness?

In this article I especially appreciated your comments on identification of scales. Many times I have had to look carefully at scales and try to figure out whether I should multiply or divide. I have also been a strong believer in simply putting down the figures in thousandths, the same way that we do on drawings. We are in full agreement on this item.

I was glad to see you attempting to get more descriptiveness in engineering descriptions. I will say in defense of the engineers that after you have been burnt by some sweeping statements, you are not so willing to use so broad a brush later.

—Forest R McFarland
Exec assistant chief engineer
Buick Motor Div
General Motors Corp

Another "Compo" Board

To the Editor:

I regret that Charles McMillan's otherwise excellent selection guide to bonded wood composition boards (Feb 29 '60, p 39) omitted reference to Formica Flakeboard, a product derived from green timber—which permits close control of properties. So that your readers can enter them in the master table on page 41 of Mr. McMillan's article, here are the pertinent property figures for this material:

Thickness	¾ to 1⅞ in
Specific gravity	0.64
Flexure strength	3500 psi
Screw-holding power	325 lb
Water absorption, 24 hr	10%

C G Reiter
Product Mgr
Formica Corp

No New Words, Please

To the Editor:

Your review of the book, *Composition of Scientific Words*, Jan 18, p 76, is entirely too friendly to gobbledegook in the form of new and unnecessary words. A certain growth of language is to be expected for new concepts but even "electron microscope" required no new word.

The sport of adding to the language new words that conceal meaning is not an admirable one. Is "epidiascope" a better term than opaque projector?

—Maurice Conklin
Meadowvale, Ont

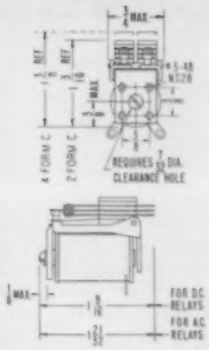
COMPACT, RELIABLE, VERSATILE . . .
this is P&B's miniature MH relay

The MH is not a new relay.

As a matter of fact, we've been building and selling this series for seven or eight years. Its reliability and exceptional longevity have been proved in business machines, airborne computers and a host of other products.

Engineers like its fast action, its small size, its light weight. They like the wide selection of contact forms . . . up to 18 springs (9 per stack, DC) as well as the fact MH relays can be furnished to switch loads ranging from dry circuit to over 5 amps at 115 volts, 60 cycle resistive.

A multiple choice of terminations add to the MH's versatility. This relay, for example, can be adapted for printed circuits, furnished with taper tabs or a long list of other terminals. Get all the facts by calling your nearest P&B sales engineer today.



MH ENGINEERING DATA

GENERAL:

Breakdown Voltage: 500 volts RMS between all elements.

Ambient Temperatures: −45° C to +85° C. (−65° C to +125° C on special order.)

Shock: 30g on special order.

Vibration: 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps. on special order.

Weight: 2½ ozs. max. (open relay)

Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:

Arrangements: Up to 9 springs per stack.

Material: ⅛" silver standard. Palladium or gold alloy also available.

Load: Dry circuits to 5 amps @ 115V AC res.

COILS:

Resistance: 22,000 ohms max.

Power: 100 mw per movable min. to 4 watts at 25° C max. (200 mw min. to meet max. shock/vibration spec.)

Duty: DC: Continuous. AC: Intermittent (Two pole relay max.) open. Sealed units supplied with full wave rectifier inside can.

Voltages: DC: Up to 110 volts. AC: Up to 230 volts 60 cycles.

The relays below are variations of the MH relay structure.

MA LATCHING
Electrical latch, mechanical reset. Small, versatile and offered with selection of contact arrangements.

MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.

MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

CIRCLE 29 ON READER SERVICE CARD

this R & M motor puts the "Drive" in IBM electric typewriters!

Almost twelve years have elapsed since International Business Machines Corporation used its first R&M motor to power its electric typewriters. Since then R&M has supplied thousands upon thousands of these special motors for IBM's world-wide typewriter trade. In order to meet varying electrical conditions the world over, they are now supplied in 21 different voltages and frequencies.

IBM proposed strict requirements for powering their machine. The motor must have high starting torque for quick response . . . run very quietly . . . cooler than normal . . . fit a limited space . . . and have stamina to perform dependably year after year. Within a short period of time, R&M delivered specifications for the right design—a dynamically balanced motor that fulfilled all of IBM's standards, including reliable operation that covers thousands of hours between check-ups.

A lot of fingers have gone over the keys since R&M produced its first IBM typewriter motor, but we still subject each IBM power unit to 100% inspection. Moreover, we constantly work with IBM—and all our customers—to improve our motors and to adapt them to the ever-changing requirements of customers' products.

R&M's experience in custom-designing motors for hundreds of products, and our facilities to produce a design at low cost, are at your service. Perhaps your problem can be met with a standard *"off-the-shelf"* power unit. If so, we'll tell you . . . and recommend the right R&M motor for the job. For power by either custom or standard fractional HP motors . . . and performance that will give you a big competitive advantage . . . get in touch with Robbins & Myers today! Write for Bulletin No. 450-PRE

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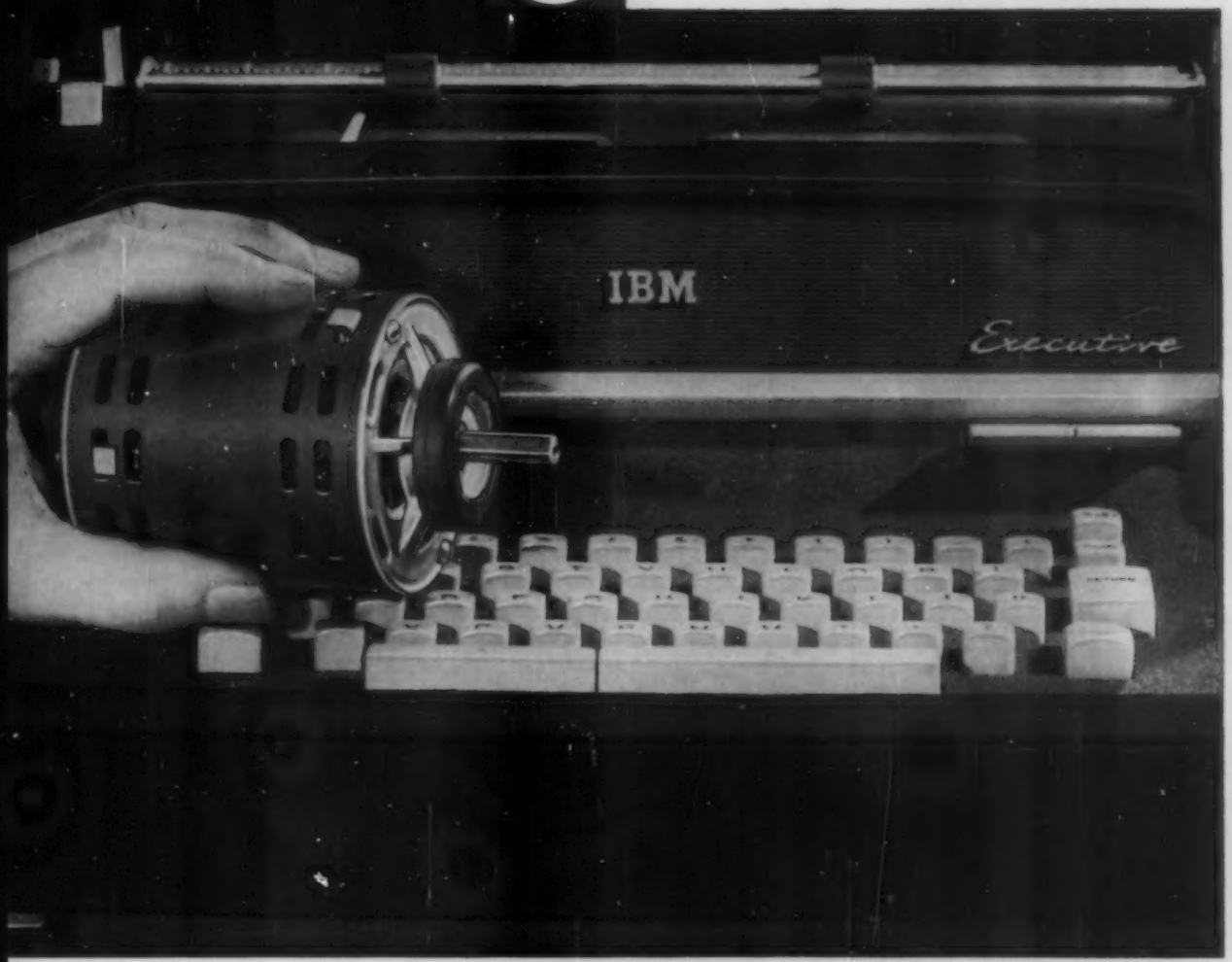
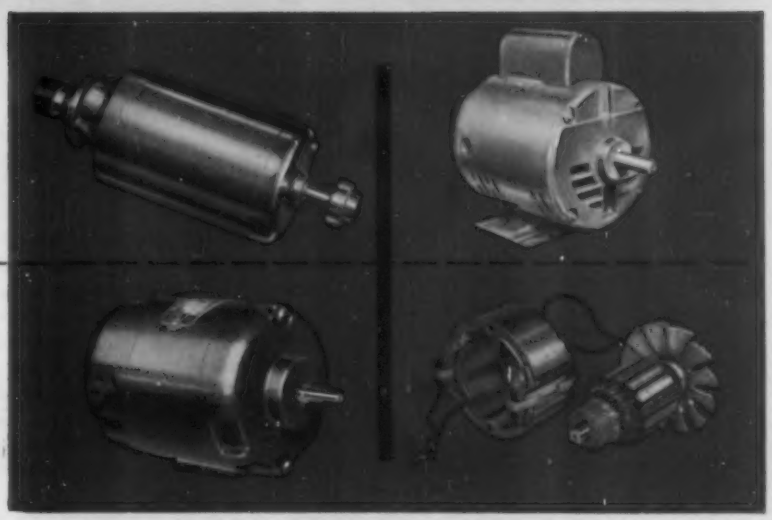
(other ratings up to 200 horsepower)



At left, Retractable Capstan Motor . . . shaft of this special R&M fractional HP motor rotates and also moves axially. Manufactured for IBM's 727 Magnetic Tape Unit.

At right, Standard Fractional HP Motors . . . a wide range of types, sizes and mountings for DC, single or polyphase AC; all standard voltages and frequencies.



At left, Standard Universal Motors . . . ratings from 1/50 to 1/2 HP. Choice of end, pad or foot mountings to permit design versatility. Custom designs also available.

At right, Series Motor Parts . . . precision-made series, universal or polyphase high-cycle motor parts. All types and sizes engineered to your requirements.

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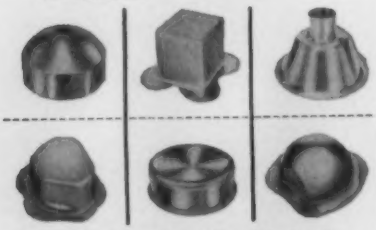

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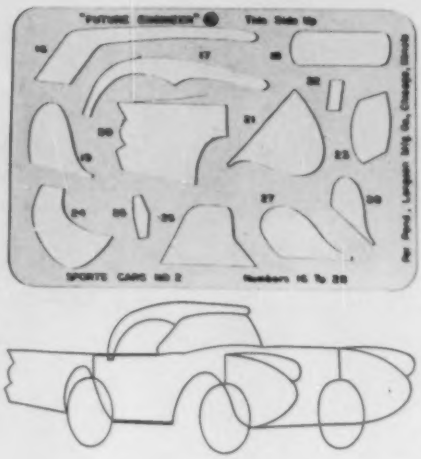
FOR YOUR INFORMATION (personal)

For young auto-designers

A templet set for designing sports cars is now available from the same source as the Jet and Missile set for future engineers. (*PE*—Nov 30 '59, p 42). The set consists of two plastic cards (only one is shown) that contain outlines for wheels, windshields, hoods, fenders and other vital parts. The price: $1 each, (3 for $2.50) from Design-Ette Inc, 940 South Fifth St, Princeton, Ill.



Get yourself a "moon drop"

"Go and catch a falling star," advised English poet John Donne back in the 16th century. But today astronomers have added a new twist—"moon drops."

Scientists have long speculated that some so-called meteorites were actually fragments torn from the moon's surface, not planetoids or bits of matter from outer space. Now, pictures of the far side of the moon, lend credence to that belief. The reason: the far side of the moon seems much smoother and less pockmarked than the side toward the earth.

Possibly, astronomers theorize, the earth has been pulling on the moon's face—a force that has caused pieces to come loose and fall to earth. Objects so far identified as possibly having originated on the moon are porous in structure, indicating that the moon has a lightweight, foamed-rock crust. So if you find a lava-like burned-out bit of matter, you may have found some moon.

Corrosion isn't all bad

The chemical compounds created by oxidation and similar corrosive reactions are often the best protection for the underlying metal.

For instance, as F. L. LaQue of INCO points out, the rate of corrosion of cast iron and steel pipe lines can be greatly reduced by minimizing fluctuations in temperature and pressure, since these interfere with retention of protective rusts on iron. Likewise, rather than trying to clean out all rust periodically, it's better to allow for it by using a pipe large enough to accommodate some rust accumulation.

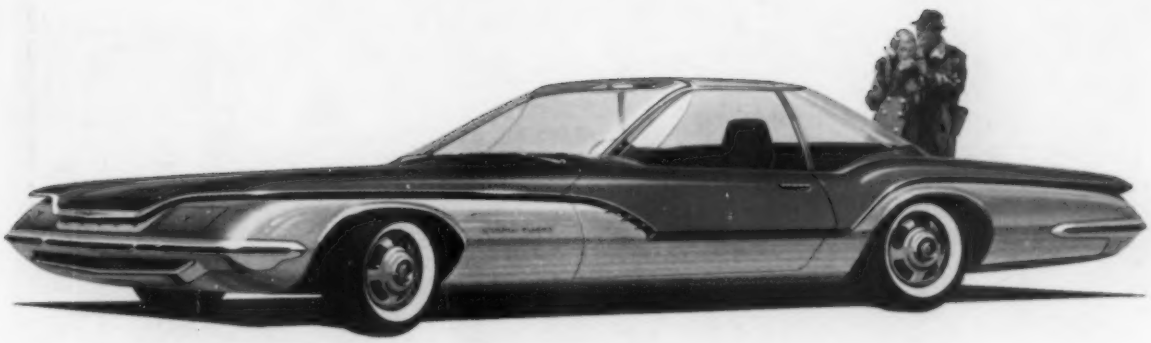
Paradoxically, too, soft water—so desirable for ring-free tubbing—is likely to be more corrosive to iron than hard water.

He also emphasizes a basic INCO finding: a little protection is worse than none at all, and exposure to a small volume of a corrosive medium may be worse than to a lot of it. For instance, washing machine tubs are more likely to corrode between uses, if left damp, than when filled with hot, soapy water.

The same is true of insect screens. When fully exposed, they'll be wet by the rain; but quickly dried by sun and wind. When partly protected, moisture lingers, and corrosion begins.

The moral: either use corrosion-resistant pipes, tanks, fittings and screens (stainless, nickel and monel, of course) or learn to take full advantage of those corrosion products. —ARG

CIRCLE 32 ON READER SERVICE CARD
CIRCLE 33 ON READER SERVICE CARD→



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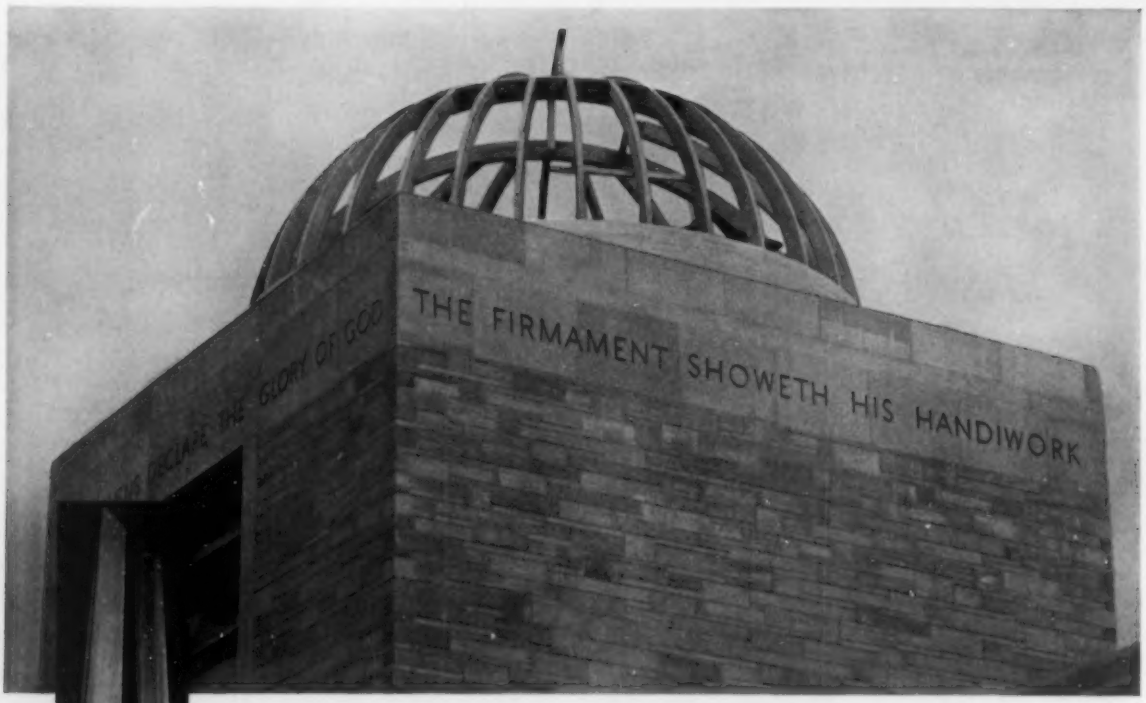

from deflector bars...to observatory domes...

GAMBLE solves problems with WOOD!

PROBLEM: Solid wood conveyor deflector bars were splitting and breaking from repeated impact of conveyed objects, causing downtime expense.

SOLUTION: Gamble wood engineers developed a *laminated hickory* deflector bar—thinner and more resilient, yet with greater and more uniform strength (due to lamination and the characteristics of hickory).

PROBLEM: Butler University, Indianapolis, needed a hemispherical dome for its J. I. Holcomb Observatory. The material for the 360-degree-rotating dome had to offer maximum dimensional stability *plus* beauty in keeping with the overall design.

SOLUTION: Gamble Brothers provided curved, laminated, wooden ribs for the 24-foot Observatory dome, and another giant "umbrella frame" for the Planetarium dome.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4617 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

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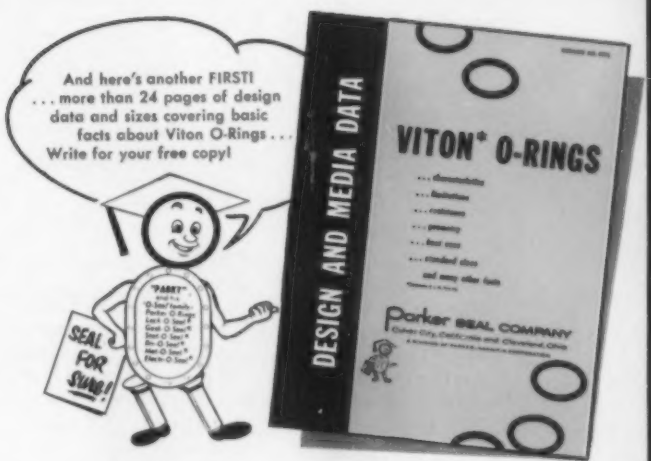
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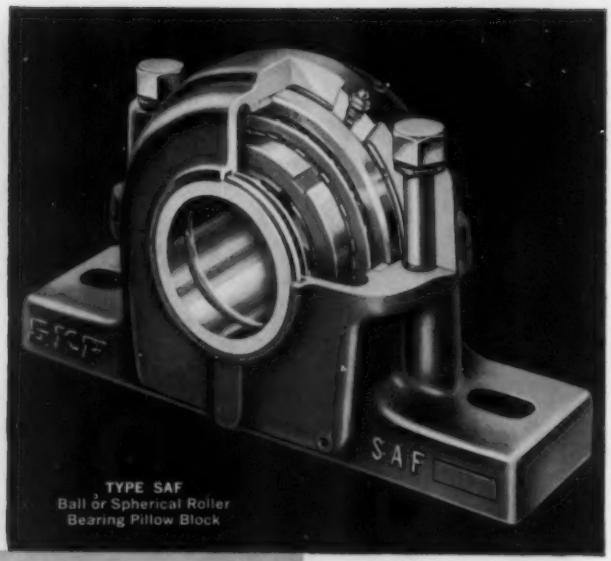
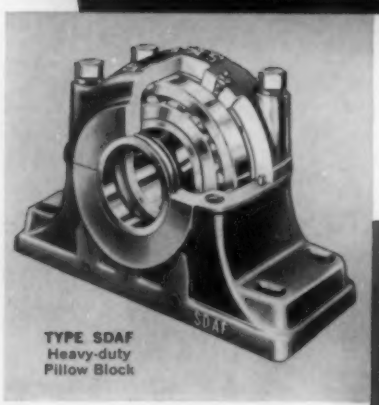


TYPE SAF
Ball or Spherical Roller
Bearing Pillow Block

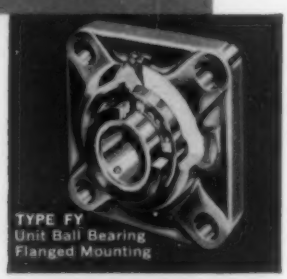
Can you get these "special" qualities in "standard" pillow blocks?



TYPE SDAF
Heavy-duty
Pillow Block

TYPE SY
Unit Ball Bearing
Pillow Block

TYPE SES
Unit Rubber-flex Ball
Bearing Pillow Block



TYPE FY
Unit Ball Bearing
Flanged Mounting

Most pillow blocks offer easy assembly and rugged housings. But can they offer you low friction, self-aligning bearing operation and efficient sealing as well?

They can—if they're the SKF pillow blocks, and flanged mounting, shown here. Type SAF, for example, comes equipped with low-friction ball or spherical roller bearings that are *inherently* self aligning. And these bearings are effectively protected by Triple-Seal rotating rings. Abrasives and corrosives can't get to them—oil or grease can't drip out.

Yet this is a standard SKF pillow block, that is competitively priced in spite of its combination of extra features. We make it for shaft sizes from ¾" to 10½", for mounting directly or with an adapter. A cast steel housing (SAFS) is available for heavy duty applications.

For details, call one of our twenty-four offices. 5938

Spherical, Cylindrical, Ball, "Tyson" Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE

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SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

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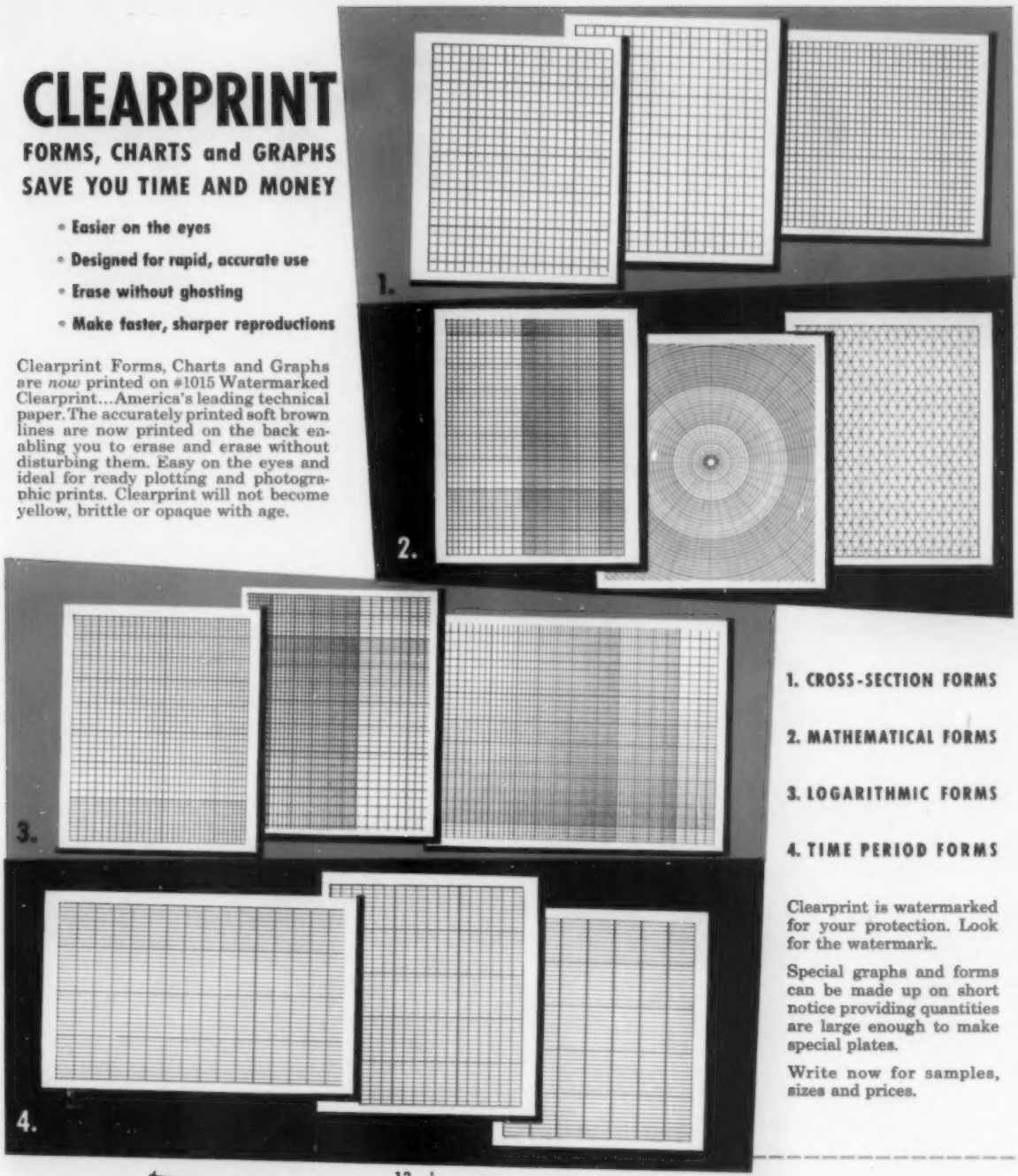

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CIRCLE 37 ON READER SERVICE CARD 37

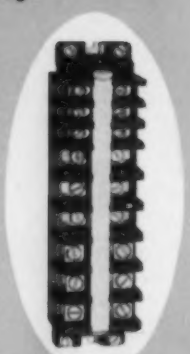
SQUARE D's *NEW* TERMINAL BLOCKS

50% MORE TERMINALS IN THE SAME SPACE!

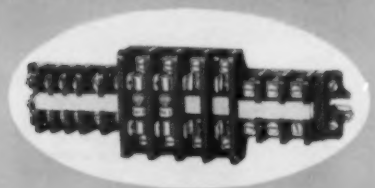
MORE FLEXIBILITY, TOO!

NOTICE *(above)* how little space is required to remove or add a Square D channel-mounted terminal block to the completely assembled unit. Especially important for a quick change when an additional terminal must be inserted into grouping.

LOOK *(at right)*... all sizes can be mounted on same channel...25 ampere pressure wire connectors, 25 to 50 ampere box lugs ...all can be interlocked together. Terminals in kit form to "do-it-yourself" or factory-assembled to standard specifications.



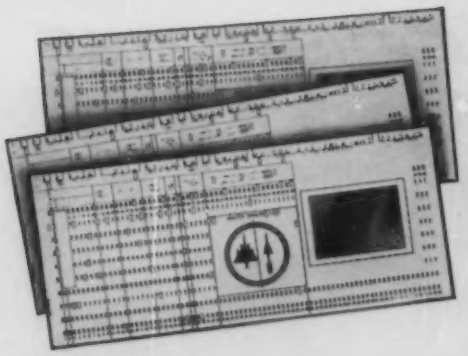
NEW...**fusible terminal block** *(below)* for protection of solenoids and other single or three-phase loads. Mounts on same channel as regular terminal blocks. Available factory-assembled or in kit form for customer assembly.



ASK YOUR SQUARE D FIELD ENGINEER
or write for Bulletin which covers details on Channel-Mounted Terminal Blocks. Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.

SQUARE D COMPANY

wherever electricity is distributed and controlled



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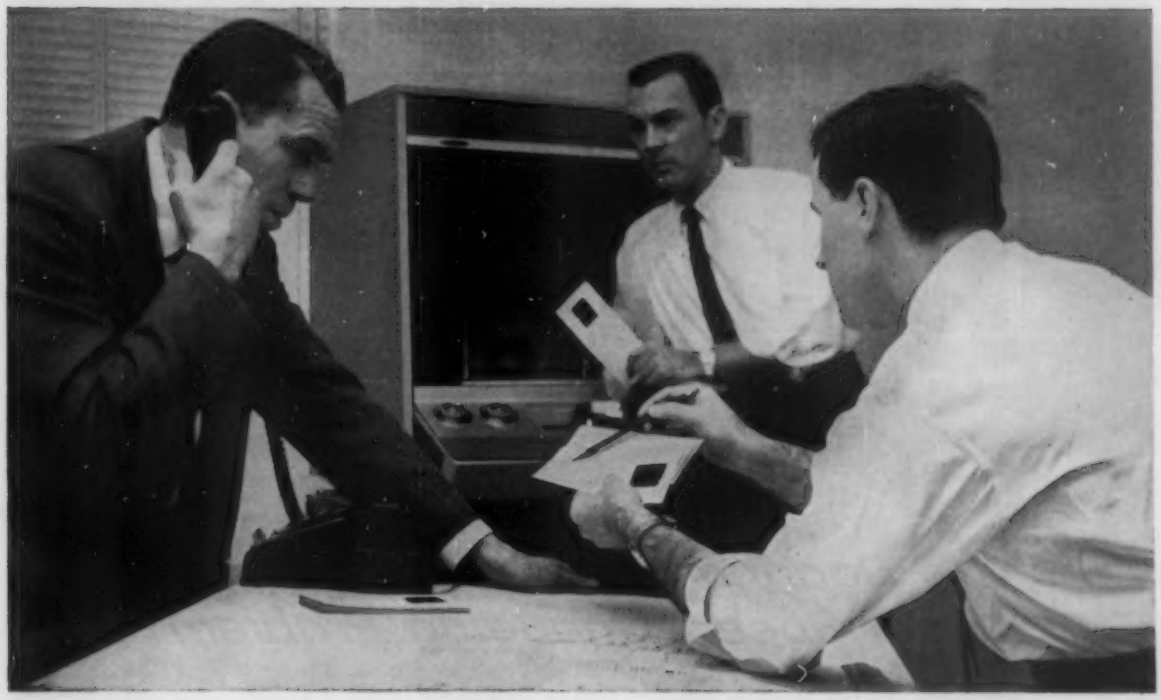

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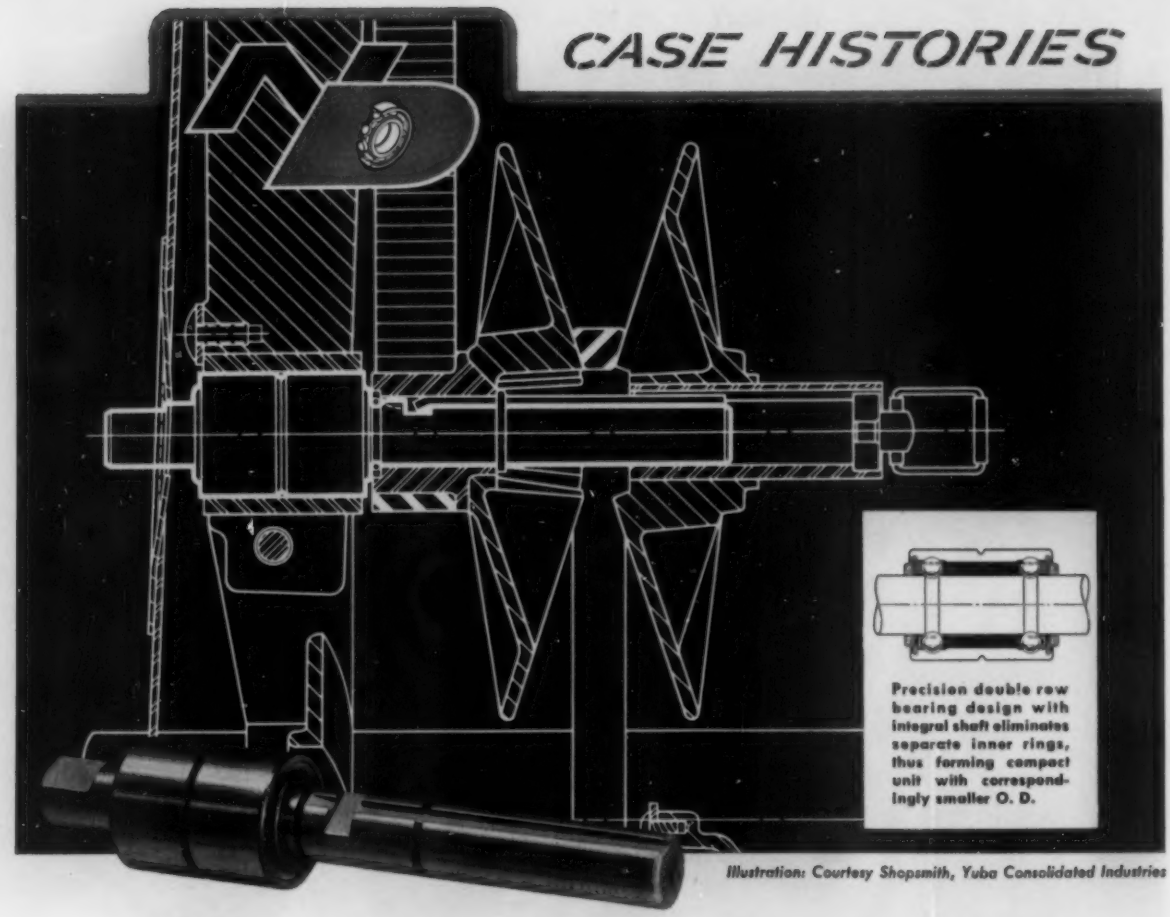

Precision double row bearing design with integral shaft eliminates separate inner rings, thus forming compact unit with correspondingly smaller O. D.

Illustration: Courtesy Shopsmith, Yuba Consolidated Industries

N/D Bearing Solves Home Power Tool Speed Changing Problem!

CUSTOMER PROBLEM:

Require low cost, compact idler shaft assembly for speed changer in popular, multi-purpose home power tool. The assembly must mount on ball bearings . . . operate at speeds up to 6000 RPM.

SOLUTION:

N/D Sales Engineer, cooperating with customer engineers, recommended a *single* N/D ball bearing —a compact integral shaft unit designed as part of idler assembly. The unit permits one of two interlocking variable pitch pulley halves to slide axially on shaft when changing pitch at high speed. This precision, automotive type fan and water pump bearing eliminates extra parts inventory and shaft machining . . . reduces assembly time. In addition to solving complex design problem, N/D's compact heavy-duty ball bearing is integrally sealed for protection against saw-generated dust . . . and lubricated-for-life for added end user sales appeal!

If *you're* designing new equipment, why not call your New Departure Sales Engineer. He probably can help engineer your application with a standard, volume-produced N/D ball bearing that will help solve your bearing problem. For more information contact New Departure Division, General Motors Corporation, Bristol, Connecticut.

Replacement ball bearings available through United Motors System and its Authorized Bearing Distributors.

NEW DEPARTURE

BALL BEARINGS

proved reliability you can build around

PRODUCT ENGINEERING HORIZONS

April 11, 1960

THE IMAGINARY COUNTRY

Flanders and Swann, the English music-hall pair, have been playing to capacity houses in New York for months. Each song is introduced by a bit of humorous patter by Flanders. Says he about one: "To illustrate the point of the next song, I must ask you to take an imaginary country . . ." After a moment, he adds, "Red China, for instance." It brings down the house.

But, on second thought, it isn't very funny, is it? For years now, we've been acting as if Red China doesn't exist, as if the million Chinese on Taiwan are a country and the 400 to 600 million on the mainland are not. Case in point: You may recall our recent article, "China builds a technology" (PE —Dec 28 '59, p 24-28). This was based on material from our Tokyo bureau chief, as a result of interviews there and in Hong Kong. We checked it here with authorities we could locate, including a former US Army interviewer of thousands of refugees. The Columbia University library supplied some statistics. We edited out or queried certain points. The whole process took about six months, and the final manuscript, perhaps a fifth of the original, seemed to hit about midway between the opinions of our authorities. We considered it as a good reporting job—not propaganda. Whether we like it or not, other countries are doing their own design engineering, and their efforts will be felt competitively by our own engineers. As we said two years ago, we *need to know*.

But an advertiser in the Midwest slapped our wrist. He felt that engineering in Red China is none of our business, quoted as his authorities two other college professors and a weekly news magazine. We were about to document a rebuttal with quotations from the newspapers and news magazines before Sputnik I orbited, then thought better of it.

This entire incident is not important except as it typifies the dual American attitude in international engineering. More and more American companies are undertaking R & D in Europe, establishing "listening posts" in other countries in the continuing search for new ideas. Many have taken licenses for foreign developments, some have licensed foreign companies or built foreign plants to compete in overseas markets or to produce products to be imported here at lower cost.

Yet we continue to put our own worst foot forward in promoting American engineering and ideas abroad. Many American companies have little or no interest in replying to foreign inquiries, apparently less in selling overseas. (Granted there are problems of red tape and exchange, but shouldn't we try anyway?) Our embassies report an increasing number of complaints about this—it seems the American is ugly in more ways than one. Government efforts to promote understanding, specifically the efforts of the executive branch, go unsupported. Meanwhile, we have a payments deficit. . . .

More and more American engineers take survey trips abroad, at the expense of companies who will not admit foreign visitors to their plants. More and more engineers worry about non-availability of foreign engineering data, while their companies refuse to release their own. Companies complain that their engineers are not aware of latest foreign developments and hire engineers from abroad, but do little or nothing to help their own men. Somehow, we're reminded of the apocryphal story of the ostrich with his head in the sand. (Ornithologists tell us that even ostriches are not *that* stupid.)

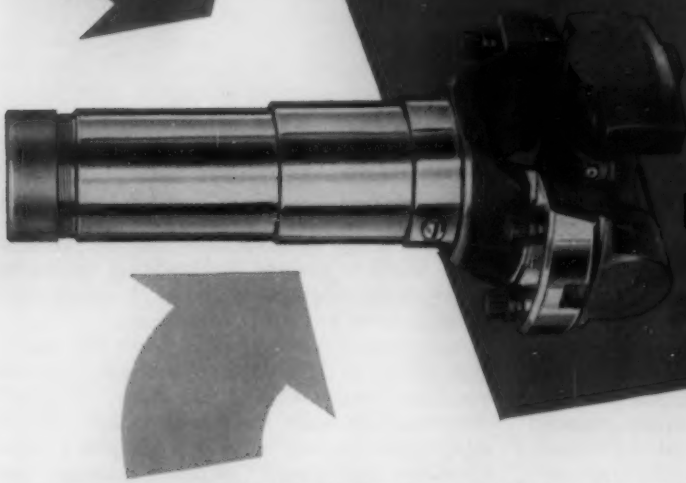
So, as editors, we propose to do what we can to broaden our sources of information, to report on an international basis. We don't think that "if we close our eyes, maybe it will go away." Somehow, the world has shrunk, so no country is an island—and there are no imaginary countries.

As an engineer said recently, "The optimists are learning Russian; the pessimists are learning Chinese."

F. Hartman

MORE MUSCLE IN A SMALLER PACKAGE... THE NEW

BLOOD BROTHERS "58WB" UNIVERSAL JOINT



To meet new drive line requirements on its 1960 model trucks, a major truck manufacturer needed a special, lightweight but strong universal joint—a unit that would provide greater torque capacity without increasing swing diameter. Rockwell-Standard engineers were consulted, and in a cooperative effort the new "58WB" was developed. It is now being used on several models in the manufacturer's 1960 line.

The design of the new "58WB" is applicable to medium-weight trucks, off-highway equipment, small crawlers and front-end loaders of approximately 1½ yards capacity. It can be made up as a complete drive line, furnished as a component part for a manufacturer's own drive line, or utilized in close-coupled drives. The "58WB" offers these outstanding advantages:

★ More capacity than any joint of comparable size. The "58WB" provides 39,000 inch pounds torque capacity with a swing diameter of only six inches!

★ Key-type yoke. Requires only four bolts for installation on original equipment. Saves downtime for repairs.

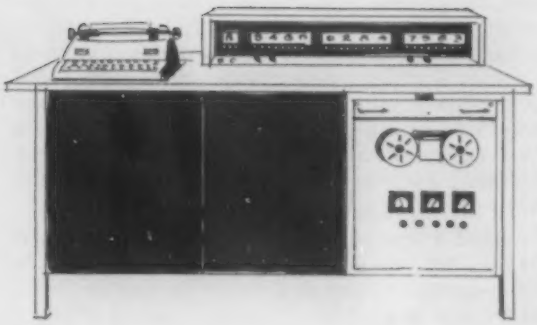
For more details about the new "58WB" or for help in solving any problems involving universal joints or drive lines, write or call us today.

Another Product of...

ROCKWELL-STANDARD
CORPORATION

Universal Joint Division, Allegan, Michigan

PRODUCT ENGINEERING
SPECIAL REPORT



design by DIGITAL COMPUTER

—how to choose *and operate the new desk-size problem solvers.*

CHARLES J LYNCH, *assistant editor*

> *"Machines have their own tricks and idiosyncrasies; they know their drivers and will play pranks on a stranger."*
> —SAMUEL BUTLER, *Erewhon, 1872*

"It's easier to teach computer operation to an engineer than engineering to a computerman." That's the reason for the growing popularity of desk-size computers bought and operated exclusively by engineers.

There are now ten such computers on the market—including six brand-new, fully transistorized machines announced in the last six months. They range widely in price, from $20,000 to $100,000, but all share one characteristic: You can learn to solve problems on one in under four hours—even less if you use a simplified code language now available on most small machines.

Maybe you've been avoiding computers in your design work, but it is a good bet that many of your problems, now approximated by longhand calculations or tested out in the form of a working prototype, could be solved in minutes, long before the design leaves the drawing board.

Here is what you'll need to know before buying, plus a selection guide to the small computers now on the market.

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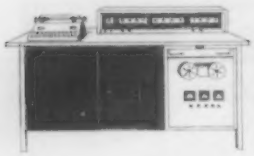
continued, next page



DIGITAL COMPUTER continued

What problems are suitable for computer solution? If mine are, should I use an analog or digital computer? What's the difference anyway? What are the terms used to describe these machines and what do they mean in problem-solving ability?

It's not a cure for all the ills of engineering, but the desk-size digital computer does have some mighty attractive features. The machines are inexpensive enough to be accepted by the man holding the purse strings, yet powerful enough to solve most all engineering problems. In principle, they're no different from their large-scale, million-dollar brothers . . . except that they're easier to operate. You pay for this simplicity only in the time it takes to solve very big problems.

The desk-size machines listed in the table on page 54 have been chosen from the wide range of available machines because they best meet the needs of the engineering department. Some are decidedly small-scale; others are classified as medium-scale. Some actually look like an el-shaped office desk; others are only "about the size of a desk" and look more like a large, steel storage cabinet. But all have been designed with the idea of providing the engineer with a speedy, simple, inexpensive problem solver.

Machines have been divided into two groups in the table, according to the way they are programed. The first group includes those that have large internal memories and are, in every way, similar to full-scale machines. These are called stored-program computers and are the most versatile and most powerful. The second group has no internal memory to speak of, is readied for problem solving by manually wiring a removable program board. They are called externally programed machines.

ENGINEERING COMPUTERS ARE DIFFERENT

Most stored-program computers (including those in the table) are classified as "general-purpose" machines, meaning they are suitable for any of the jobs commonly turned over to computers—of which only a small percentage are actual engineering problems. Although it is possible that one machine will do all jobs equally well, as a practical matter even general-purpose computers are designed with a bias toward one kind of job and must be modified if they are to do other tasks. Computers are broadly cataloged under three headings:

Scientific or engineering computers tend to have limited speed and capacity on input and output but high speed and capacity in computation circuits. Input is often by typewriter or keyboard push-button, output by typewriter or printer. Because the machine may be asked to solve several totally different problems in one day, versatility, ease of operation, and automatic procedures that reduce setup time are emphasized.

Business computers are primarily data processors. Reams of paper are reduced to neat piles of punched cards and processed in unending repetition. Their memories (high-speed storage) must be as large as those in scientific computers, but they also need plenty of additional capacity for medium-speed storage in the form of input-output equipment-card handlers, magnetic-tape transporters, high-speed printers, etc. It has been suggested that these computers were produced in the nick of time to stem the rising tide of paperwork inundating business and government. Roughly two-thirds of all digital computer equipment in use today is applied in this area.

Control computers were mostly of the analog type in the past, but have now been replaced in many areas by high-speed digital equipment. They serve as the central nerve center in a hands-off situation popularly known as automation. Input comes from pickups, transducers or sensors and output goes to drive motors and actuators placed on the equipment they control. Many control computers are special-purpose machines designed to solve only one problem or control only one kind of process, with the same computations repeated over and over. Machine tools, steel mills, navigation of aircraft and ships, chemical processing plants, all depend on control computers to make decisions and dispatch the orders that keep things running smoothly and with maximum efficiency.

OPERATION OF A SIMPLE COMPUTER

Let's eliminate the frills and examine a computer of the simplest kind. All of the equipment in a computer can be cataloged under one of five headings; input, output, memory, arithmetic, control. In our small fictional computer, we will lump these elements together into just three: a typewriter for input and output, a small box housing the memory, and a larger box containing arithmetic and control circuits.

The computer accepts two kinds of information from the input typewriter: problem data and instructions. Both kinds go into the memory as the keys of the typewriter are struck, simultaneously typing a record of the information that has been fed to the machine. When the memory has been loaded with all the necessary information, arithmetic and control circuits are set to work with the push of a button. The control unit shuttles the information back and forth between memory and arithmetic unit, processing the data step by step in accordance with the instructions and storing the answers and partial solutions back in the memory. When processing is complete to the satisfaction of all stored instructions, the memory spits up the answers and prints them out on the typewriter. All information-shuffling is dispatched at such a high rate of speed that for short problems, the operator no more than completes the last entry in the statement of the problem and the computer snaps the answer back.

PROBLEM DATA

Information is typed into the computer in the form of "words." A word is the largest piece of information that

text continued on page 46

ANALOG vs DIGITAL—what problems for which

Oddly enough, engineers who can see a clear-cut distinction between a slide rule and a desk calculator still have difficulty drawing the line between analog and digital computers. Yet that is the perfect example.

Or consider the face of your watch. Don't let the numbers fool you, the watch presents analog information—angular location of the hands represents time. But the numerical clock, with counter wheels reading in minutes and hours, is a digital display—no fractions of minutes are shown.

A digital computer deals in pure numbers—rather like the arithmetic they teach in grammar school. An analog computer deals in quantities (voltages, rotations of a shaft, etc.) where quantity represents the magnitude of problem variables (speed, time, etc.).

An electronic analog computer is just an electronic slide rule, or really a series of slide rules (or potentiometers) in which the output of the first feeds into input of the second, the second into the third, and so on in as many steps as the problem requires.

The electronic digital computer, on the other hand, is a desk calculator able to store instructions much as a piano roll stores instructions for operating the keys of the piano. It also can store numbers and so each computation is done in its turn much as man and adding machine would. But what makes it a powerful tool is its speed—potentially as great as 60,000 operations per second.

Here's what these functional differences mean in terms of speed, accuracy and cost:

Speed. Analog computers work in real time—when time is the independent variable in a problem situation, the computer displays the solution as if the problem situation were actually happening in the machine. For the most part, digital computers work in "machine time." The succession of numbers to be added and subtracted takes as long as it takes to add or subtract. Hence digital computers are somewhat slower than analog computers.

Accuracy. Barring malfunctions, a digital computer can be as accurate as required—it is only necessary to build a machine that handles the desired number of significant digits. Analogs, on the other hand, rely on carefully selected components and precision measuring instruments to achieve high accuracy—usually not better than $\pm 0.1\%$. Stability is also a factor affecting accuracy of an analog machine; even the best machines drift slightly over a long period of time, giving slightly different output readings even though input data remains constant.

Cost. Analog computers get more work out of a few components than the digital computer can. This explains why they are cheaper, ranging from $1000 to $100,000. Rock bottom for a digital computer is about $10,000 and prices over $1,000,000 are not uncommon for large machines.

How they solve problems

Whether a machine is analog or digital, before a problem can be solved, the electronic elements must be prepared (or programed) to accept the problem data and to process it in the intended fashion. To an analog computer, a program is a group of patch cords interconnecting the functional building blocks of analog mathematics. When the wiring is complete, the combined effect of all circuits is a physical representation of the equation to be solved.

In a digital computer, the program is a list of instructions stored in the memory, to be followed slavishly by the machine.

Digital machines are generally the more versatile. Neither the equation to be solved nor the class of problem is inherent in the machine. It will solve any problem that can be reduced to a series of logical steps. Further, it can alter its instructions in the course of the problem according to some programed scheme. Such is not the case in analogs. The circuits represent the equation or series of equations—to change those fixed relationships requires a physical change in machine circuitry.

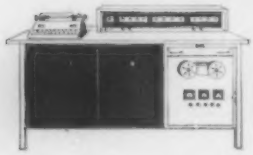
Which computer for what job

Either type of computer can be made to solve any kind of mathematical relationship—each is capable of performing all arithmetic operations, differentiation, integration, and trigonometric functions. However, specific characteristics of each make them more suitable for one job than for another.

Differentiation with respect to time, a common problem in engineering, is generally much easier to program on an analog computer. Problems that are fundamentally a series of arithmetic steps are a logical choice for digital solution. Repetitive solutions, where the same problem is solved over and over again, each time with a new set of constants, can be performed with ease on either machine. Changing an analog constant is simply a matter of twisting a dial; on a digital machine this is done by specifying that all values between certain limits be tried, and results printed out.

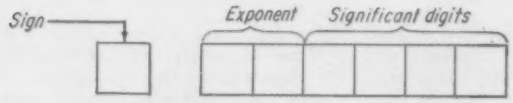
One other characteristic may have deciding influence. Analog answers are generally plotted automatically on a recorder or plotting board. Digital results normally come out in the form of typewritten copy. This, however, is only a matter of convenience and does not represent a fundamental limitation; either computer can be modified to deliver either type of output.

Some scientific problems are, of course, too small for computer solution. But a group of similar small problems (calculating stress in a beam at 100 points, for example) can be set up on a computer. Such small arithmetic tasks, in which the same equations are solved over and over again with new 'ata, can add up to an aggregate saving that is clearly worthwhile.



DIGITAL COMPUTER continued

can be digested at one bite. Input to the machine, whether an instruction or numerical data, must be broken up into words of a limited number of decimal characters. Let us assume our computer can handle six-digit words. A word typed into the machine to represent numerical data looks like this:



where each cell (except the cell for the sign) represents a number between 0 and 9. With this particular word structure, numerical data is allowed only four significant digits. The remaining spaces are filled by the sign and the exponent digits, which indicate where the decimal point is to be placed.

Exponents are expressed to the base 10, but to avoid need for both positive and negative exponents, they are usually written in the "excess 50" code. Exponent 50 indicates that the decimal point is placed before the first significant digit, 10^0 is indicated by exponent 53, and 10^{-3} by exponent 47. With this **floating-point** notation, the computer keeps track of the decimal point. in **fixed-point** computers (or floating-point computers being operated in the fixed-point mode) the operator enters all data so that the decimal point precedes the first digit and then keeps track of the appropriate power of 10 by pencil-and-paper arithmetic. Or he can program the machine to do this bookkeeping job automatically in a series of separate calculations done while the principle elements of the computer wrestle with the problem data.

INSTRUCTING THE MACHINE

All words, whether data or instructions, are first stored in memory locations, usually over 2000 of them. Each storage location is designated by an address number, similar to post-office box numbers. Once stored at a particular address, the word stays there until the machine is cleared or a new word is entered over it, erasing the previous entry. When called for in computation, it is simply copied out but not erased.

An instruction word looks like this:

Notice that it contains not only a two-digit code describing the instruction, but an address. Because there is room for only one address in each word, this is called a **single-address** machine.

The instruction tells what is to be done (add, subtract, multiply,etc.) while the address tells where to find the data to be operated on. In an instruction, the sign cell is not filled except to indicate a special kind of instruction.

COMPUTER SOLUTION—calculus via arithmetic

Your biggest hurdle is the realization that digital computers can't do anything more than the simplest arithmetical operations. All the common ones—addition, subtraction, multiplication, and in most cases, division—are available with a single command from the operator. Some machines also have square root command in their vocabulary but, for the most part, digital circuits don't know a square root or integral sign from a treble-clef notation—all these more complex operations must be reduced to combinations of the fundamental arithmetic operations.

With the appearance of the computer on the mathematical scene, it became necessary to unlimber an old mathematical tool, numerical analysis. This is the branch of mathematics that provides methods for transforming nonarithmetic problems into problems consisting of only simple arithmetic steps. It is possible, for example, to integrate a function by adding the areas of infinitesimally narrow strips under the curve representing the function. It's rarely done this way, of course, because the method is tedious and for most problems we have calculus to do it for us. But the computer knows no calculus and can't be taught. It does the problem the tedious way, but does it so fast that the operation is entirely practical.

Numerical analysis also turns algebraic problems into problems in arithmetic. Consider a problem with two equations and two unknowns. With a pencil, paper and simple algebra, these can be reduced to one equation and one unknown by subtracting one equation from the other—or by solving one equation for one unknown in terms of the other unknown, and substituting. Because a computer can't manipulate the variables this way, it has to sneak up on the solution by successive approximation. This is tedious, of course, but with numerical analysis, there are shortcuts that reduce this operation to relatively few repetitive steps. Writing such a program is very difficult.

Computer solutions, though crude, permit a wider range of problems to be solved. Fifty equations in 50 unknowns is an almost unthinkably complex problem by paper-and-pencil methods—the average desk-size computer will whip through the lot in perhaps a little more than an hour.

SIMPLE PROBLEM

Suppose we wish to set up the machine to do a very simple problem—simpler, in this case, than any problem we would normally ask a powerful computer to do. The equation to be solved is:

$$a = b + c \quad \text{for } b = 1.127 \text{ and } c = 0.0568$$

Because data and instruction words, once typed into the memory, cannot be distinguished, one from the other, it is common to store them in two different parts of the memory and differentiate between them by some code system. If, for example, we wish to store the data in the first and second address and the instructions in the tenth and following address, we would begin by typing

22 0001

where the code number 22 indicates that the word to be entered is data, not instruction, and it is to be placed in memory location 0001. These first numbers do not themselves go to the memory; they only prepare the machine for entry of data in memory location 0001. Then the data word can be typed in. The machine assumes that data following should go into consecutive addresses and will automatically return the carriage, tabulate it up one space, and type the next address to be ready for the second entry. The data is entered as follows:

22 0001 +51 1127
0002 +49 5680

In the instructions, it will first be necessary to take the value for a from the memory and put it in the arithmetic section (called the accumulator). Then the value for b will be put in the accumulator and added to a. The sum will then be returned to the memory, stored in some specified location and subsequently taken from there and printed out on the typewriter. Thus we write:

20 0010

where 20 is the code indicating that the following words are instruction words–the first to be put in location 10. This is followed by the list of instructions

20 0010 04 0001
0011 06 0002
0012 09 0004
0013 07 0004

In the instruction code chosen for this machine, 04 directs the machine to clear the accumulator and enter the number indicated by the address, 06 means add the number indicated by the address to the one in the accumulator, 09 means store in the indicated address the value (in this case, a sum) in the accumulator, 07 means type out the contents of the address indicated. Thus, when all these words have been typed out, the machine is given a signal and it automatically types out

+51 1184

The answer is really 1.1838 but the machine rounds it off to the nearest value with four significant digits.

GLOSSARY OF COMPUTER CHARACTERISTICS

Actual machines vary somewhat from this idealized example. Following is a summary of those differences, including features found on many desk-size machines.

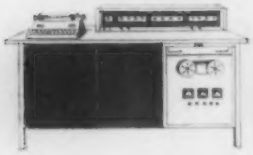
Length of Words

Computer words in stored-program machines vary from 6 to 12 decimal digits. Even the largest machines rarely have words exceeding 12 digits. Some machines with shorter words have provision for operating in **double precision.** Here, a single word occupies the space alloted to two words in the memory and, in effect, a data word can have roughly twice the number of significant digits; the instruction word, however, is entered as before and occupies only a one-word space in the memory. The Bendix G-15 is the only desk-size machine that has this feature built-in.

Computers that have fixed word length are most common in scientific calculations though some scientific computers have **variable word length.** The recently announced IBM 1620 is an example. In a variable-word length computer, data words can be any length. The length of an instruction word, on the other hand, is dependent on the design of the machine and will be fixed. Variable-word computers are more sparing of memory space because data words take only as much room as is needed. This feature is more common in data processing where access time and conservation of storage space is of great importance.

Computers that allow only short data words are adequate for non-repetitive calculations. But many routine problems require "loop" solutions that call for a series of successive approximations and when round-off errors occur, they can build up to significant proportions. For this

THESE KNOBS AND BUTTONS, plus the keys of a conventional electric typewriter, are the only controls the operator need deal with in the Autonetics Recomp II computer—typical of the controls on most desk-size machines. Unlike some other desk-size machines, however, some typewriter operations are duplicated on the keyboard so that it is possible to control the machine completely from this console. Under the hood above the keyboard is a digital-display register that shows data or instruction as it is entered by the operator.



reason, an engineering machine should have a capacity of at least six significant digits per word.

Number of Addresses

A **single-address** word structure was illustrated in our hypothetical computer; there was only one address per instruction word. Most desk-size computers are single-address machines. In a **two-address** machine, the first address indicates where one of the operands will be found and the second address gives the location of the other operand. A **three-address** machine gives location of both operands and also indicates where result is to be put. In a **four-address** word the additional address tells the machine where the next program instruction is. There are also combination forms: the one-plus-one address system; and the two-plus-one address system, in which the plus indicates the address of the next instruction. Other variations are possible: the Recomp II, for example, operates as a single-address machine but squeezes two instructions and two addresses into each word.

Floating Point

In engineering calculations, it is convenient to be able to express numerical input data in floating-point notation, as in the example above, rather than in the more clumsy fixed point. In fixed point, all numbers—whole or decimal—are entered as decimals, with decimal point to the left of the first significant figure. Before beginning computation in fixed point, you must make rough estimates of the answer. This is to ensure that significant digits will not be chopped off when the machine cuts the data down to word-size pieces, and that small numbers do not get lost when there are operations involving both very small numbers and very large numbers. This "scaling" operation though not too much bother for repetitive data-processing tasks, can be a very troublesome chore in calculations where the order of magnitude of the answers is unknown before calculation starts.

Floating point has its drawbacks too. Unless it is built into the hardware, the translating system that converts floating-point numbers at input to fixed-point numbers inside, must be stored in the memory and referred to by the machine each time it makes a move. This not only uses up valuable memory space, it is a slow procedure and may boost computation time by a factor of two or more.

Vocabulary

In the example above, only four commands, or instructions, were illustrated: "clear and place in the accumulator" . . . "add to accumulator" . . . "store in memory" . . . "print out". Most machines have provisions for a large vocabulary of commands varying from a minimum of about 16 to a maximum of over 100. In addition to the arithmetic commands that might be found on the keys of a conventional desk calculator, there are a variety of special

INPUT TYPEWRITER automatically produces a punched tape in the attached housing at left. This one (a Flexowriter made by Commercial Controls Corp, Rochester 2, NY) is standard equipment for the Royal McBee LGP-30. Ready-prepared tapes can also be read into the computer memory through the attached device, but speed is slow (10 characters per sec) and Royal McBee recommends that a photoelectric reader be rented for this purpose. Some computer installations have one or more of these tape-punching typewriters for preparing programs on an "off-line" basis so that programing does not tie up computing equipment.

commands incident to the bookkeeping necessary in any electronic calculation. Examples are: "shift right or left" . . . "halt" . . . "transfer control" . . . "punch paper tape" . . . "ring bell" . . . etc.

The number of commands suggests how powerful the machine is. But it is also related to the word structure (a command in a three-address machine may do the work of three commands in single-address format) so that it is not always possible to compare two machines by the size of their vocabulary. It also gives some notion of the difficulty of programing. In general, the larger the number of commands, the more difficult the programing. A small number of commands eases the job of learning to operate the machine; but with a limited vocabulary it may take many instructions to program the same operation done by one instruction on a more powerful machine.

Simplified Programing

The programing of all digital computers has been simplified somewhat inasmuch as the operation always deals with decimal digits even though binary arithmetic is the usual mode of internal operation. To simplify the writing of programs, a number of schemes have been developed. The simplest, most rudimentary, of these is

the **mnemonic code** where symbols replace numbered commands—an add command may be indicated in the program by the letters AD or a "+" sign; a divide command, by DV or slash mark (/). This eases the chore of remembering or looking up the code number for each program instruction.

Other programing-simplification techniques give a significant reduction in the amount of programing effort, often save several steps in the procedure.

A common and universally applied programing simplifier is the subroutine—a sort of prepackaged program for simple computations that recur frequently. Because digital computers are simple-minded animals, which must be carefully led by the hand through each step of the problem, programing common operations such as roots and trigonometric functions every time they occur can be a tedious, time-consuming chore.

Subroutines simplify this task. These partial programs can be read into the memory from a prepared paper tape, automatically listing the necessary instructions. A square-root subroutine is shown in the accompanying sketch. Subroutines for many common operations are supplied as part of the basic equipment for most machines. These include: roots, powers, logarithms, trigonometric functions.

Automatic Programing

A number of other more powerful programs are also widely used for speeding translation between the mathematical language of engineers and the electronic language of the machine. They are based on the principle that the logic capacity of the machine can be called on to do the translating job as well as the computation. Some of the more powerful ones permit the engineer to feed in equations exactly as they would normally be written—operations symbols, equals signs, parentheses, superscripts—without regard for instruction codes, addresses or machine words.

There are two types available for most desk-size machines: **interpreters** and **compilers.** Both are stored in the memory and both convert the engineer-written program (written in "pseudo-code") to a machine-language program. Interpreters do this conversion job during the course of computation as the program instructions pass, one by one, from the memory to the control circuit. Compilers make up a complete machine-language program before computation begins; then use this program to solve the problem. Compiling sometimes takes two passes through the machine; one pass to deliver a detailed program in machine language and a second pass to solve the problem.

Compilers are generally more powerful—sometimes turning one source-program instruction into a great many machine-language instructions—and do not occupy valuable memory space during computation as do the interpretive routines. Interpretive routines are usually more versatile and less susceptible to operator error because pseudo-code instructions are translated into machine-language instructions on a one-for-one basis.

Index Registers

Because the computer is limited to arithmetic operations, many problems, as well as many of the nonarithmetic

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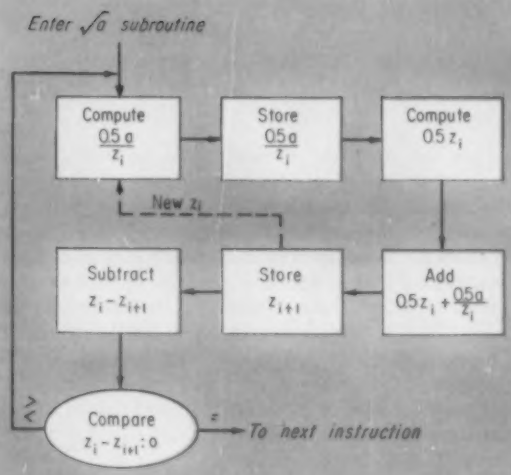


SQUARE ROOT SUBROUTINE creeps up on the answer by method of successive approximation. Diagram above is a routine for solving the equation

$$\sqrt{a} = \tfrac{1}{2}\left(Z_i + \frac{a}{Z_i}\right) = Z_{i+1}$$

where a is any number between 0 and 1. Numbers larger than 1 must be multiplied by a power of 10 before the square root can be found. In fixed-point machines, numbers will have already been reduced to a number less than 1 before entering the computer.

For example, to find the square root of 2, the scaling would occur before the number entered the subroutine.

$$\sqrt{2} = \sqrt{0.02 \times 10^2} = 10\sqrt{0.02}$$

The machine begins with a guess of $Z_i = 0.5$

$$\sqrt{0.02} = \tfrac{1}{2}\left(0.5 + \frac{0.02}{0.5}\right) = 0.252$$

Then subtracting 0.252 from 0.5, it finds the answer is not zero and therefore returns to try again with the new guess of $Z_{i+1} = 0.252$. The next answers, in order, are:

$$Z_{i+2} = 0.165682$$
$$Z_{i+3} = 0.143198$$
$$Z_{i+4} = 0.141432$$
$$Z_{i+5} = 0.141422$$

It continues, until subtracting the last guess from the next-to-the-last guess gives 0. This occurs when $Z_{i+6} = 0.141421$. Here the machine stops, stores the result, and goes on to the next instruction in the main part of the program.

operations the computer performs, must be arrived at by methods of successive approximation. This requires some way of repeating the same set of instructions over and over again, using new or modified sets of data each time around.

To allow the same set of instructions to draw data from various addresses, it is necessary to have some means of modifying the address connected with an instruction. This is usually done by putting the address in the accumulator and adding a fixed quantity to it. In some computers addresses can be modified quickly and conveniently with special built-in hardware called an index register or B-box. Of the desk-size machines, however, only the new Royal McBee RPC-4000 has this feature.

Input—Output

Because engineering problems usually have a large number of instructions and small amount of data, engineering computers do not need the variety of input-output machinery required of data processing, for example. But in addition to a typewriter, which is standard on most desk-size machines, other ways are provided to get information in and out.

Punched tape is next in importance to the typewriter—which is very slow by computer standards (10 characters/sec, max). Tapes are punched mechanically (10 char/sec or better) and are usually read photoelectrically at a maximum speed of about 500 char/sec. These are convenient for entering previously prepared data, instructions, automatic coding routines, subroutines, or for removing large quantities of information in a permanent form that will be easy to return to the machine if necessary. Tape reading speed is important; no one wants to wait two hours while the machine reads a long, ready-prepared program. A speed of 150 characters per sec is about the slowest that can be tolerated.

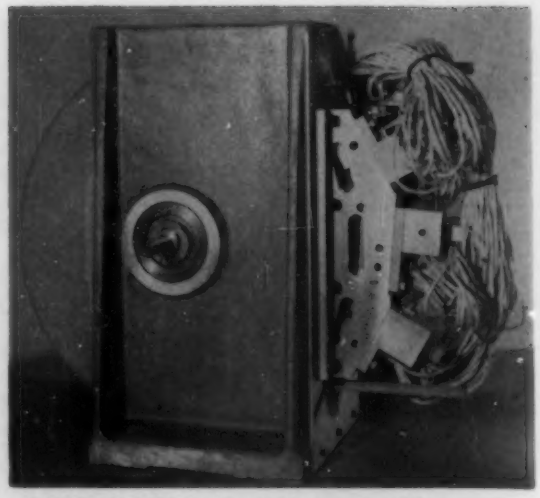
Magnetic-tape machines serve as the input and output and offer higher speed. They are more expensive than punched tape, and do not offer the permanence of holes in paper. But for reading in large blocks of information, their speed is not easily matched.

Punched cards sometimes act as input/output in engineering applications. The format is such that it allows rearrangement of cards—a feature needed more in large scientific machines and data-processing applications. Speed here is about 600 char/sec.

Line-printers are common for larger computers. These are ultrafast typewriters for producing typewritten information at a speed more closely matching that of large machines. A fast line-printer can turn out 100-character-per-line copy at a speed of 1500 lines per minute.

Memory

In principle there is actually not much difference between memory and input-output. Both must be able to store information that comes from the machine on demand.



MEMORY DRUM captures pulses representing binary digits and stores them magnetically on its surface. "Read" and "write" heads are mounted on the brackets at right—one of each for every track on the drum. The memory in the Bendix G-15 computer (drum shown above) is a volatile storage device—information circulates continuously, is read, erased and rewritten in the same place each time the drum makes a complete revolution. This helps reduce access time but creates a hazard of losing all the data on the drum if the machine is accidentally shut off during operation.

The difference lies in where the command comes from and the speed at which it must be answered. Memory devices take orders from the machine and must find and deliver the needed information quickly; input-output is generally activated by the operator and is not so demanding from the standpoint of time.

Because of the similarity in function, similar equipment is used. Magnetic tapes often store large quantities of information for delivery on demand. Speed of finding the information, called **access time**, is relatively slow, however, as the machine must often search the entire tape to find the desired information.

Most common kind of memory is the **magnetic drum**. Information is stored as magnetized spots on the surface of the drum, which rotates at high speed under magnetic recording heads. With a large number of magnetic tracks on drum surface and "read" and "write" heads for each track, a large amount of information can be stored this way. Disadvantage is that it must wait until the information comes under a read head, which can be a significant period of time. Access time averages about 8

text continued on page 52

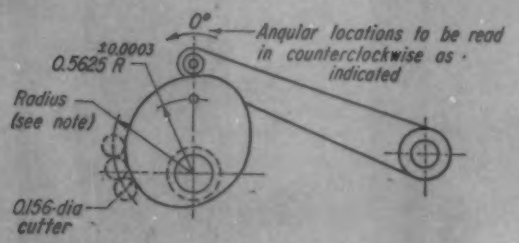
THESE PROBLEMS ARE READY-MADE FOR COMPUTERS

Only two types of problems are impractical on digital computers: (1) those that don't reduce to a sequence of logical steps; and (2) those that require more storage capacity than is available in the machine. These restrictions do not eliminate many engineering problems. Most large problems in mechanical engineerng have been successfully turned over to computer solution. Typical examples: vibration analysis, stress analysis, systems evaluation, factor analysis, thermodynamic calculations.

Of course, some problems are too small to make efficient use of computer capabilities, but there are a large number of problems of modest size that are eminently suited to such automatic means. Among these are: statistical calculations, mean and standard deviation of a large number of data points, calculation of tables where a simple equation is solved for a variety of values for the variables, small sets of simultaneous equations.

Shown below are two small problems wherein the repetitive solution of a simple equation gave quick answers and saved a considerable number of engineering man-hours. Compare these with pencil-and-paper methods discussed in the articles, "Faster Way to Select Change Gears," Feb 15 '60, p 64; and "Roll Cams—Stop and Go on Demand," Jan 19 '59, p 68.

PROBLEM: Design a rocker-arm cam for an airborne computer such that when angular input to the cam is proportional to the logarithm of the ratio between static pressure and total pressure, the angular output from the rocker arm is proportional to the logarithm of Mach number.



The equations to be solved give the radius of the cam, R, at any input angle, c, or

$$R = K_1 \sin [K_2 - c + K_3 \log f(M)]$$

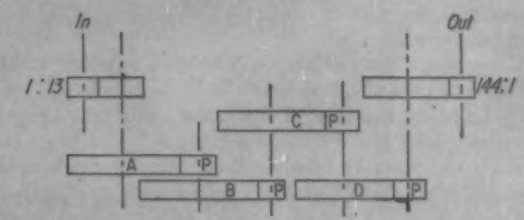
where K_1, K_2, K_3 are constants and $f(M)$ is a function of Mach number.

SOLUTION: The problem was set up on a Bendix G-15 computer. Because the angle (within brackets) cannot be computed directly, an iterative procedure was used to give quarter-degree points within ±5 seconds of arc from trial values of Mach number. When quarter-degree points were found, angle and radius were typed out and the computer proceeded to the next point. A portion of the type-out is shown below.

MACH	ANGLE (degrees)	RADIUS (inches)
0.179	0.00	0.8125
0.179	0.25	0.8117
0.179	0.50	0.8110
0.179	0.75	0.8102
0.180	1.00	0.8095
0.180	1.25	0.8087
0.180	1.50	0.8080
0.181	1.75	0.8072
0.181	2.00	0.8065

Fifty cams, involving six to eight thousand equations per cam, were designed this way in about 40 hours. It is estimated that the same job would have taken an engineer with desk calculator four to five weeks per cam. This represents a time-saving of about 150 to 1 and an estimated cost saving of 50 to 1 or higher.

PROBLEM: Find all possible ratios, from input to output, that can be made with combinations of available gears arranged as shown below. Tabulate these ratios in ascending order.



SOLUTION: The equation for the over-all ratio is:

$$\frac{\text{Out}}{\text{In}} = \frac{1}{13} \times \frac{A}{P} \times \frac{B}{P} \times \frac{C}{P} \times \frac{D}{P} \times \frac{144}{1}$$

and the ranges for each gear, as available from stock, are:

P = 18 or 24 teeth
A = 60 to 120 teeth, in increments of 6
B = 66 to 126 teeth, in increments of 6
C = 72 to 132 teeth, in increments of 6
D = 78 to 138 teeth, in increments of 6

The computer program is written as a series of successive multiplications repeated for each ratio. On each pass through the program the computer picks up a new value (indicated by program instructions) for one or more of the gears. A sample of the print-out is shown below. From this completed sheet, printed about as fast as the typewriter will type, the engineer picks the ratio that best fits his application.

GEAR RATIO		NUMBER OF TEETH			
P = 24	P = 18	A	B	C	D
732.1999	2346.6668	60	66	72	78
864.3750	2592.2223	60	66	78	78
866.2501	2737.7779	60	66	84	78
877.5000	2773.3333	60	72	78	78
927.9299	2933.3334	60	66	90	78

millisec. A variation of this is the **magnetic disk** in which tracks are concentric circles.

Fastest of current memory devices is the **magnetic core.** It is a **random access** memory—information stored in any core or group of cores can be recovered without scanning the entire storage device. It is also fastest of available memories, with access times averaging about 0.01 millisec.

EXTERNALLY PROGRAMED MACHINES

Two machines shown in the tables are cataloged separately because their operating characteristics are significantly different from the internally programed machines. This group of smaller computers is not as versatile nor as complex as the fully automatic machine. Instead of a large memory where instructions or problem data are kept together, they have separate storage locations for instructions and problem data; instructions are set up on a pinboard or plugboard while data goes into a small magnetic drum, with capacity usually less than 300 words.

Externally programed machines are manually operated from a keyboard with buttons for all fundamental arithmetic operations and additional buttons for typical computer operations such as print-out, store, transfer. These operations can also be controlled automatically by the program board.

To program the machine it is only necessary to make appropriate connections at the holes of the board. On the plug board in the Clary DE-60, the operator interconnects two holes (one for the step number in the program, one for the operation) with a short piece of patch cord that has plugs at both ends. The pinboard on the Burroughs E-101 has a row of holes for each step number in the program. The desired operation is prepared by dropping a combination of pins in holes of the row.

To provide additional capacity for data and instructions, externally programed machines have paper tape-readers. Information is not read from punched tape into the memory all at one clip, as internally programed machines do, but is supplied to functional circuits from this source as it is needed, one piece at a time. Depending on the capacity of the program board, tape will be used for either primary or secondary storage of instructions. Burroughs, for example, advises that the operator put the main program on the pinboards and use the punched tape for programs that overflow the capacity of pinboards and for subroutines.

Biggest disadvantage of these machines is that, with limited high-speed storage capacity, they are inefficient for complex problems, particularly when data and instructions must be carried on punched tape. However, they can solve matrix inversion and differential equations, and their similarity to desk calculators makes them easier to understand and program. Further, they are inexpensive to operate and are therefore most suitable for solving problems on an individualized, nonproduction basis.

THE FINANCIAL SIDE

Though a marvelous plaything for engineers, the tab for capital investment and operating expense must eventually be paid and justified. Management opinion will probably be colored by the widespread rumor—or fact—that computers have been oversold in the past. One

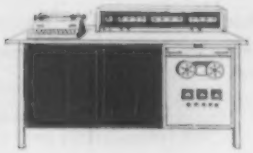
text continued on page 56

STORED-

AUTONETICS RECOMP II

BENDIX G-15

CONTROL DATA 160



PROGRAM MACHINES

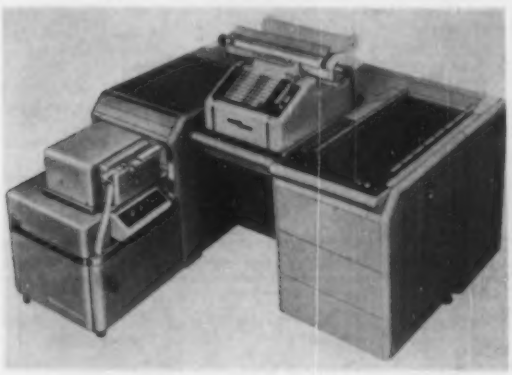
IBM 1620

MONROBOT MARK XI

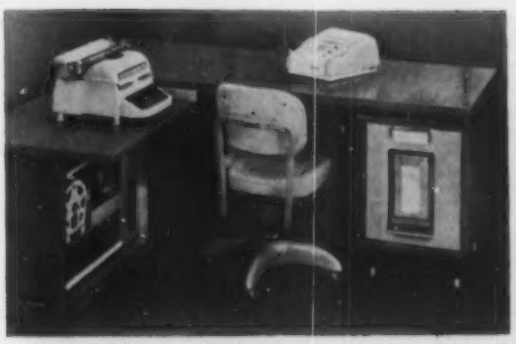
ROYAL PRECISION LGP-30

ROYAL PRECISION RPC-4000

EXTERNALLY PROGRAMED MACHINES



BURROUGHS E-101



CLARY DE-60

Stored-program Machines

What's Available in

Manufacturer and Type	Operating Speed, (incl. access time), millisec	Word Length	Instruction Type	Vocabulary, number basic instructions	Arithmetic Mode	Floating Point	Electronics
Autonetics Recomp II Autonetics Industrial Products, Div of North American Aviation, 3584 Wilshire Blvd, Los Angeles 5	Floating point: adding, 1.35 multiplying, 12.4 Fixed point: adding, 0.54 multiplying, 10.8	40 bits or 12 decimal digits, plus sign	Single-address (two instructions per word)	49	Binary	Built-in (9 of the 49 instructions)	Transistorized
Bendix G-15 Bendix Computer, Div of Bendix Aviation Corp, 5630 Arbor Vitae St., Los Angeles 45	Fixed point: adding, 0.54 multiplying, 16.7	29 bits or 7 decimal digits, plus sign	2 + 1 address	80	Binary	Programed	450 tubes 2800 diodes
Control Data 160 Control Data Corp, 501 Park Ave, Minneapolis 15	Fixed point: adding, 0.0128 multiplying, 1.0	12 bits (data in 22-, 33- or 44-bit words)	Single-address	62	Binary	Programed	Transistorized
IBM 1620 International Business Machines Corp, 590 Madison Ave, New York 22	Fixed point: adding, 0.56 multiplying, 5.96	Variable (instruction word, 12 digits)	2-address	68 expanded	Decimal	Programed	Transistorized
Monrobot Mark XI Monroe Calculating Machine Co Inc, Orange, NJ	Fixed point: adding, 9.0 multiplying, 34.0	32 bits or 9 decimal digits, plus sign	Single-address (two instructions per word)	27	Binary	Programed	Transistorized
PB 250 Packard-Bell Electronics Corp, 12333 West Olympic Blvd, Los Angeles 64	.....	21 bits	.....	.....	.....	.....	Transistorized
					Details to be announced May 2, 1960		
Royal Precision LGP-30 Royal McBee Corp, Westchester Ave, Port Chester, NY	Fixed point: adding, 2.25 multiplying, 18.0	31 bits or 9 decimal digits, plus sign	Single-address	16	Binary	Programed	113 tubes 1450 diodes
Royal Precision RPC-4000	Fixed point: adding, 1.0 multiplying, 18.0	32 bits or 9 decimal digits, plus sign	1 + 1 address	32	Binary	Programed	Transistorized

. . . and for comparison with a large-scale scientific computer

IBM 7090	Floating point: adding, 0.014 multiplying, 0.024 Fixed point: adding, 0.004 multiplying, 0.025	36 bits or 10 decimal digits, plus sign	Single-address	More than 200	Binary	Built-in	Transistorized

Externally Programed Machines

Manufacturer and Type*	Operating Speed, (incl. access time), millisec	Max Number of Digits	Floating Point	Electronics	Storage for Data			Capacity of Program Board
					Type	Number of Locations	Average Access Time, Millisec	
Burroughs E-101 Burroughs Corp, Equipment and Systems Marketing Div, Detroit 32	adding, 50.0 multiplying, 250.0	12, plus sign	Programed	250 tubes 2000 diodes	Drum	220	8.5	128 instructions
Clary DE-60 Clary Corp, 408 Junipero St, San Gabriel, Calif	adding, 60.0 multiplying, 220.0	18, plus sign	Programed	Transistorized	Drum	32 (128 add'l, optional)	8.5	119 instructions

* Production of IBM 610 Autopoint was discontinued Mar. 1, 1960.

Desk-Size Computers

Input (without optional accessories)		Storage			Output (without optional accessories)		Optional accessories	Delivery Time, mo.	Quantity Delivered	First Delivery	Rental, basic system, $/mo	Price, basic system, $
Type	Speed, characters/sec	Type	Words	Average Access Time, millisec	Type	Speed, characters/sec						
Keyboard Punched tape	Manua 400	Disk Disk	4,080 16	9.0 0.95	Typewriter Tape punch	10 20	None announced	3	Over 36	Dec 1958	3000	95,000
Typewriter Punched tape	Manual 225	Drum Drum	2,160 16	14.5 0.54	Typewriter Tape punch	10 17	Digital differential analyzer; magnetic tape; punched-card input/output; hi-speed tape reader; (400 char/sec); graph plotter	1½–2	270	1955	1485	49,500
Keyboard Punched tape	Manual 350	Mag. core	4,096	0.0064	Tape punch	60	Typewriter; punched-card magnetic-tape input/output; line printer	6	0	Apr 1960	.....	60,000
Typewriter Punched tape	Manual 150	Mag. core	20,000 alpha-numeric digits	0.02	Typewriter Tape punch	10 15	None announced	12	0	Oct 1960	1600	74,500
Typewriter Punched tape	Manual 20	Drum	1,024	6.0	Typewriter Tape punch	10 20	Card reader and punch	2	0	Apr 1960	600.25	24,500
.....	.....	Mag. core	.....	.....	.....	..	.....	....	.....	....	.....	about 30,000
Typewriter Punched tape	Manual 10	Drum	4,096	8.0	Typewriter Tape punch	10 10	High-speed tape reader (200 char/sec) and punch (20 char/sec)	1–2	360	1956	1100	49,500
Typewriter Punched tape	Manual 60	Drum Drum	8,000 8	8.5 1.0	Typewriter Tape punch	12 30	High-speed tape reader (500 char/sec) and punch (300 char/sec)	....	0	July 1960	1750	87,500
Card reader Mag. tape	250 cards/min 62,500	Mag. Core	32,768	0.002	Card punch Mag. tape Line printer	100 card/min 62,500 char/sec 150 lines/min	Card-to-tape and tape-to-card (or tape-to-printer) converters	....	.....	Dec 1959	63,500	2,898,000

Additional Storage		Output (incl. optional accessories), char./sec	Delivery Time, mo.	Quantity Delivered	First Delivery	Rental, basic system, $/mo	Price, basic system, $
Type	Speed, characters/sec						
Punched tape Punched card	20	Gang printer, 24 Tape punch, 20	1–2	205	1955	1000	38,325
Punched tape (optional)	20	Typewriter, 10 Line printer, 20 Tape punch, 20	3	5	Jan 1960	540	18,000

PRODUCT ENGINEERING
APRIL 11, 1960
PAGES 54 and 55

computer expert estimates that 54% of small-scale machines in operation before 1958 fell short of the company's expectations, compared to only 33% for large-scale machines. These figures, however, include every sort of computer application and in the case of the large machines, the application was probably more carefully surveyed, and estimates of anticipated improvement more realistic.

When the management hurdles have been cleared, there is still the question of whether to buy or rent. All machine manufacturers offer both possibilities and rental price generally runs from 2 to 4% of purchase price. Most users rent (about 80% according to best industry estimates) because with this plan, maintenance is free—if the machine is purchased you must furnish your own maintenance personnel. Renting is also cheaper in the short run and provides a hedge against obsolescence.

Once the computer is in the plant, it's not necessarily a matter of sink or swim, unaided. In addition to the maintenance plan, the computer manufacturers also provide computer schools to get the company engineers started on the right foot. They maintain large libraries of subroutines, and ready-prepared, off-the-shelf programs of common problems (usually in the form of punched tape) are available to their clients at no cost. Moreover, users of similar machines have formed their own groups for the purpose of exchanging programs, problems and know-how. Two well-organized groups of this kind: POOL, an association of Royal-McBee owners and operators, and EXCHANGE, the Bendix users' organization.

WHEN THEY'RE WORTH IT

How do you know when you have sufficient computational work to justify the expense of a computer? Most users admit they gambled. "There's almost no way of estimating just what a computer will do to the way your shop is run," says a typical user. "We made a few guesses —then took a flier and hoped for the best." Some firms have a number of clerks doing routine calculations with desk calculators and thus can compare salaries of clerks with cost of computer time for the same work. This gives the most accurate estimate, but the situation is too rare to be of much help for most engineering departments.

It is likewise difficult to set a break-even point on operating time below which the operation will cease to be profitable. One group of consulting engineers has rented a computer for a year with the idea that it would be put to work on one very complex problem. The machine is running less than four hours a day but even this is less expensive, they estimate, than having the work done by outside agency. Most users find that if the workload is sufficient to make it worth the gamble to begin with, it becomes more profitable as engineers find what it can do and the workload increases.

The failure of scientific machines to meet expectations can usually be traced to lack of competent computer personnel. Unless engineers learn to exercise the machine's full capabilities it will be operated much like a speedy automatic desk calculator. Engineers must learn that the computer offers not only a means for increasing speed and accuracy of calculations now being done, but is also applicable to problems that were beyond the scope of practical mathematics 10 years ago. With this insight, the computer will contribute to better-engineered products —and reduce engineering costs as well. ■

ELECTRONIC ARITHMETIC—

■ From the operator's standpoint, all computers are decimal machines; data is entered as decimal figures and answers appear as decimal figures. But, except with an all-decimal machine, this can only be done because the designers have built-in a translating circuit that converts decimal information into other kinds of information before it enters the machine proper. Inside, numbers are handled in three ways: decimal, binary, binary-coded decimal.

Binary and binary-coded decimal machines are most common. Binary computers are least complex from the electronic point of view but require a decimal-to-binary converter on input (and re-converter on output)—an awkward electronic process. Decimal machines avoid this process but do not make very efficient use of the electronic components, which are fundamentally binary elements. The compromise is the binary-coded decimal computer. For comparison here is the same number written three ways:

Decimal	Binary	Binary-coded Decimal
350	101011110	0110 1000 0011

In the straight binary form the number 101011110 means $1 \times 2^8 + 1 \times 2^6 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 1 \times 2^1$ in the same way that the number 350 in common decimal notation means $3 \times 10^2 + 5 \times 10^1$. In binary-coded, each decimal number is represented separately by 4 binary digits (bits). Because these can be arranged 16 different ways to give 16 different decimal numbers, six of these combinations will have to be wasted. In the excess-three notation, illustrated above, the first three and last three combinations of binary digits are discarded rather than the last six. Thus, a binary three is a zero in binary-coded decimal. This is common in computers because it not only distributes the waste, but has advantages in performing many of the arithmetic operations.

In the machine, numbers are represented by voltage pulses. In binary and binary-coded decimal machines, a pulse represents the binary digit 1, lack of a pulse indicates zero (in some machines, the situation is reversed). The pulse that represents the 2^8 digit is distinguished from the pulse representing the 2^0 digit by the time at which it occurs. This is called *serial operation* and is the most common form. In *parallel operation*, all pulses occur at the same time on separate wires, with a wire for each power of the base 2. Computers that operate in parallel are faster, but more complex, than serial machines. One desk-size computer (and a few large-scale machines) have parallel logic.

Why binary

Binary is much easier to work with inside the machine from the standpoint of electronics than is the decimal form. Two-state devices are common in electronics; a switch is either on or off, a tube either conducts or it doesn't, a piece of metal is either magnetized or it isn't. To store a decimal number, 10 two-state devices must be connected so that only one of them is on at a time, thus indicating which of 10 figures is being represented. The other nine are off and do no work. Those same 10 two-state devices can be used to store a binary number 10 digits long, or the equivalent of the number 1023 in decimal.

Binary, then, not only makes the most of the available

electronic components, it is a much more compact system. Binary also has another advantage: it simplifies arithmetic. Computers add two numbers by a method known as table addition, or "table look-up." When a table adder is presented with two digits, its output automatically registers the sum. In binary arithmetic, this is particularly simple because only four possible combinations can enter the adder: two zeroes, a zero and a one, a one and a zero, and two ones. And because the sum of zero plus one, and one plus zero is the same, there are only three possible outputs: zero, one, and one with one to carry. Circuits that perform this task consist of only a few components and are much simpler than a decimal adder. Subtraction, mulitplication and division are also simplified.

Subtraction by addition seems a curious process, but the computer does it with ease. Consider a typical subtraction problem in decimal arithmetic: 350 − 255 = 125. To subtract by adding, first find the complement of the subtrahend, add it to the minuend and strike off the carry.

1000	775
−225	+350
775	1) 125

In binary, the first step is simplified because the complement of any binary number can be found by changing every zero to one and every one to zero, and adding one to the least significant digit. The complement of 011100001 (or 225) is 100011110 + 00000001 = 100011111. Adding this to the binary equivalent of 350 gives

100011111
+101011110
1) 001111101 = 125

Multiplication is not difficult either: 5 × 11 in binary is

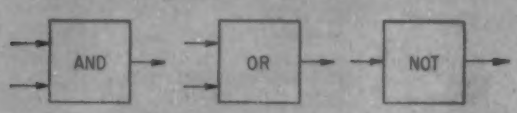
1011
0101
1011
1011
110111

As in conventional multiplication, the numbers appearing in the column to be added are shifted one place for each digit of the multiplier. But in binary, it is only necessary to copy the multiplicand whenever a one appears in the multiplier; when a zero appears, the column is shifted without copying.

Division is performed by successively subtracting the divisor from the dividend, counting the number of subtractions it takes to make the result negative. When the result is negative, the last subtraction is returned and the number of subtractions recorded as the first digit of the quotient. For the second digit of the quotient, the cycle is repeated with a shifted remainder as the dividend.

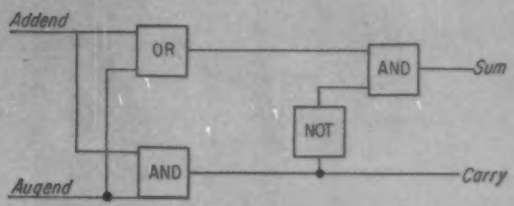
AND, OR, and NOT

Three logic circuits carry a large share of the burden in most computers. Electronically they are very simple. Schematically, AND, OR, and NOT circuits can be represented this way:



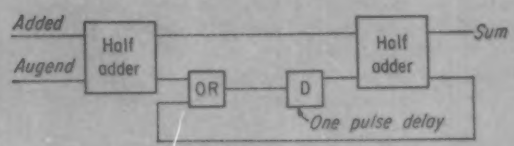
AND and OR are both shown with two inputs although, in practice, there are sometimes more. The AND element passes an output pulse only when pulses appear simultaneously at all inputs. The OR element passes an output pulse when there is a pulse at any or all of the inputs. The NOT circuit produces a steady flow of output pulses, except when there is a pulse on the input.

These three circuits can be assembled into a table adder. It must perform this job: No pulse on output with no pulse on either input; pulse on output with pulse on either input, no output pulse but a carry pulse with pulses on both inputs. This is a common form of table adder made up of only the three logic circuits.



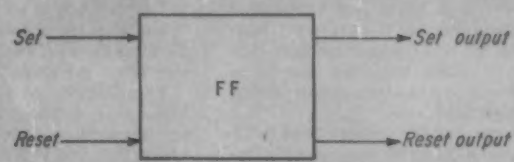
A pulse on either input will pass through the OR circuit but not through the first AND. From the OR, the pulse will travel through the following AND (because the NOT is producing pulses) to give a pulse indicating the sum, 1. With a pulse on both inputs, both the AND and OR produce a pulse. But the pulse from the AND stops the pulse stream from the NOT and prevents the OR pulses from passing through the AND. This gives a sum of 0 and a carry of 1. Such a circuit is called a half-adder.

Two half-adders can be put together to give a full adder.



The delay circuit forces the carry pulse to be added to the following pair of digits as in pencil-and-paper addition. Thus, two strings of pulses at the input representing two binary numbers in serial, produces one string of pulses at the output representing the sum.

Another important circuit in a computer is the bistable switch or flip-flop. Like toggle switches these elements are either in one state or the other and always give an indication of what state they are in. Two vacuum tubes will make a flip-flop, but with magnetic and solid-state elements the circuitry can be greatly simplified. Schematically a flip-flop looks like this

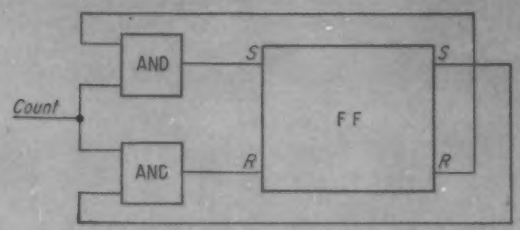


Signals from both outputs are a steady voltage, not pulses; when the flip-flop is set, a steady voltage appears

continued, next page

at the set output and no (or very little) voltage at the reset output. The circuit can be triggered with pulses but if it is set, a pulse on set input will have no effect whereas a pulse on the reset input will switch it to give a signal at the reset output. Pulses are never applied to both inputs at once.

Flip-flops do several jobs in computer arithmetic: temporary storage, counting, decoding, comparing signs, and many others. Counting is one of the most important of these functions. This circuit illustrates how a binary counter might be constructed from this basic element.



If the flip-flop is not set, the high reset output will allow the first count pulse to pass through the upper AND but not through the lower AND and thus cause the flip-flop to be set. The second count pulse will reset the circuit and produce a carry pulse. The capacity of this circuit is only one: It will be set whenever the number of count pulses is odd, and reset when the number is even. The capacity can be increased to three by wiring one output lead to the count input of a second counter circuit. Every other pulse on the first counter will set and reset the second circuit. If the "set" condition is assumed to indicate a one, and the "reset" condition zero, the first circuit will represent the 2^0 place in binary numbers; the second, the 2^1 place. With 10 counters all strung together by their carry outputs, the 10th counter registers the 2^9 place. This combination can be made to show an accumulated total of 1023 pulses (or bits) if there is an electrical (or visual) indication of which flip-flops are set and which are not. On the 1024th count all counters return to zero.

With counters and adders, any basic arithmetic operation can be performed—addition, subtraction, multiplication, division. The counters keep track of successive additions or subtractions for multiplication and division. Actual computers often have circuits somewhat more sophisticated, but many machines have circuits not substantially different from those described.

Reliability

With pulse traffic moving from one part of the computer to another at the speed of light, it is not difficult to imagine a pulse getting lost somewhere, with catastrophic results. This is possible, of course, but a wrong answer in a digital computer is usually so wrong that it will be caught and corrected. However, several precautionary measures are taken to reduce this possibility to the minimum.

One method is the "check bit." In a binary-coded decimal machine, for example, each decimal number may be represented inside the machine by a string of four pulses or bits, plus one additional bit that trails along after the bits representing the number. The fifth bit is given the job of turning each number into an even number of pulses. If the binary number has three pulses, as in the number 0111, the machine automatically puts a pulse in the check-bit position to make the total even. Binary numbers that already have an even number of bits don't get a check bit.

All numbers are processed through a scanner that counts to see if each has an even number of bits. If not, the machine usually asks to have the number repeated and if the repeat fails to pass, an error signal appears at the console. Notice, however, that this method only catches a loss of an odd number of bits and will allow numbers missing even numbers of bits to pass.

There are several other methods of guarding against errors. Most machines have check procedure to be followed before a problem is entered. This sometimes includes applying an overvoltage to all components to induce premature failure if one is weak. Also, it probably includes a check routine, read into the machine from the punched-tape reader. This routine makes a functional test of the computer's arithmetic and control circuits. ■

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EDITOR'S NOTE: For further information on computers other than just desk-sized digital machines, see:

Mechanical & Electronic Computers in the Engineering Department, Mid-Oct 1955, p A-14. Some general considerations when applying any computer—large or small, analog or digital—to design problems.

Are Computers Oversold? Sept 9 '57, p 40. Although most engineering applications are financially successful, not all data processing installations meet expectations.

Big Computers Solve Packaged Problems Economically, June 2 '58, p 28. You don't have to own a computer; service centers can handle your problems inexpensively if an off-the-shelf program is available.

Solution by Analogy, Jan 26 '59, p 28. How does an analog computer work and what problems will it solve.

Thinking Machines Need Thoughtful Men, May 4 '59, p 32. What's ahead in computers—a look ten or more years into the future.

For a more detailed discussion of computers (how they work, what they can do, how they fit in with other modern engineering concepts) the author recommends the following books to mechanical engineers:

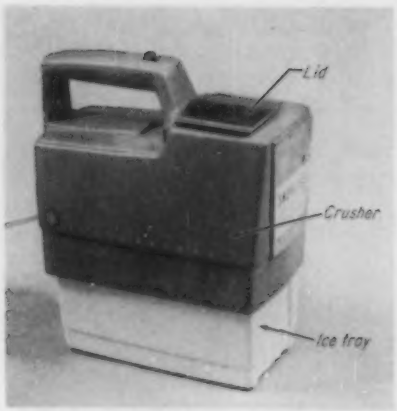
Bowden, B. V. "Faster Than Thought," Sir Isaac Pitman & Sons, Ltd, London, 1953. $8.50.

Goode and Machol. "System Engineering," McGraw-Hill Book Co, NYC, 1957. $11.50.

McCormick, E. M. "Digital Computer Primer," McGraw-Hill Book Co, NYC, 1959. $7.50.

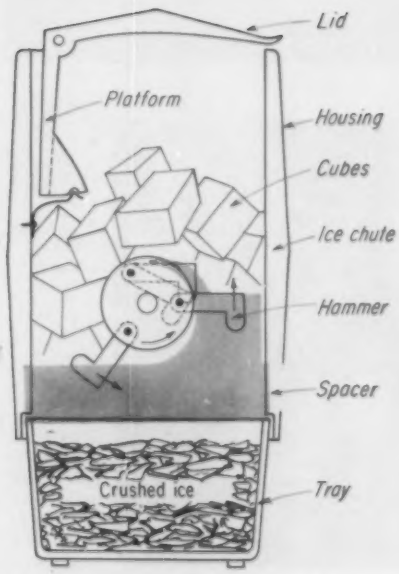
Murphy, John S. "Basics of Digital Computers, Vol 1, 2, 3," John F Rider Publisher, Inc, NYC. $7.50.

Stibitz and Larrivee. "Mathematics and Computers," McGraw-Hill Book Co., NYC, 1957. $5.

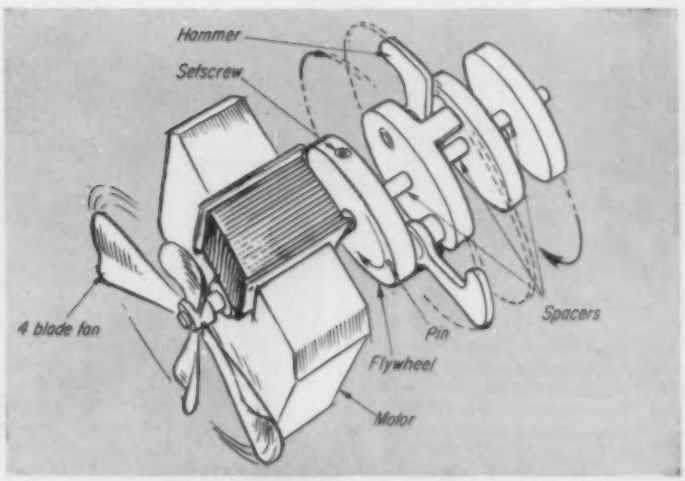


Electric Mill Breaks the Ice

Pivoting miniature hammers, driven by centrifugal force, crush cubes. When blocked, they swing out of way to prevent stalling. Safety cover protects user, permits continuous operation.



WHOLE ICE CUBES are set on the platform and the lid snapped closed. Closing the lid drops the ice into contact with the whirling hammers. Bronze leaf spring holds lid closed. Platform section blocks the chute when lid is open. This keeps user's hands from contacting any moving parts and prevents ice chips from flying out when unit is loaded while in operation. Cracked ice is driven downward through the spacers into the storage tray, which holds approximately one quart—about two trays of cubes.

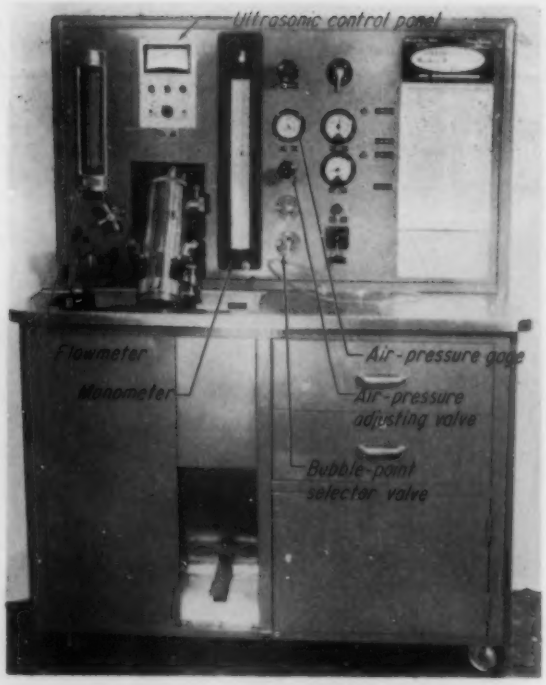


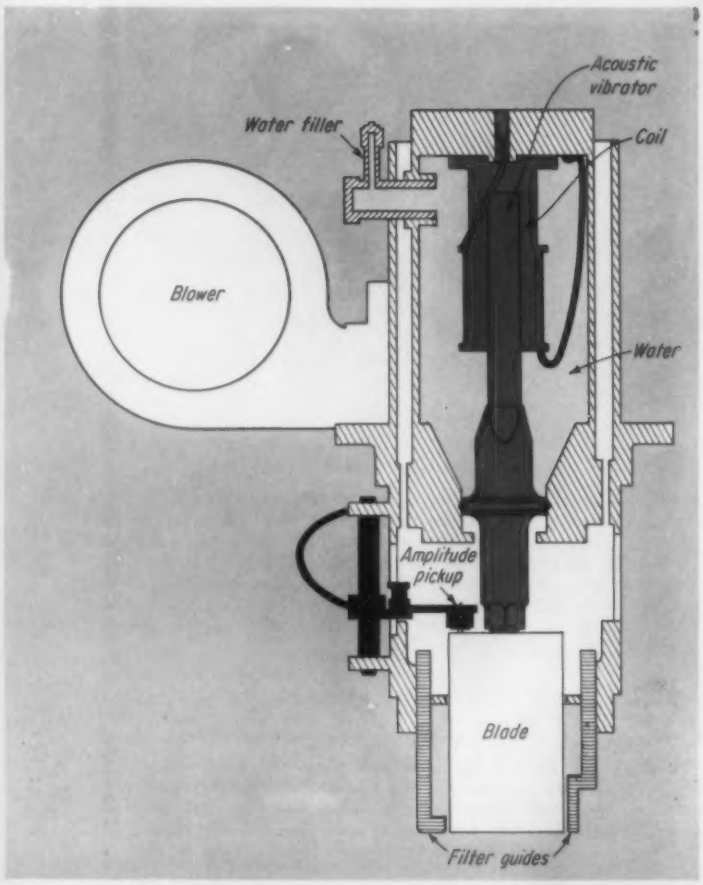
HAMMER MILL is small-scale version of heavy-duty units used to crush rock and ores. Four flywheels on the motor shaft have three hammers mounted between them on pins. As the shaft rotates, the loosely pinned hammers are flung outward by centrifugal force, striking the ice 165 blows per second. After the hammers strike the ice, they bounce inward between the flywheels and are then whirled outward again to repeat the cycle. This arrangement prevents the motor from stalling, and allows crusher to start even when it is fully loaded.

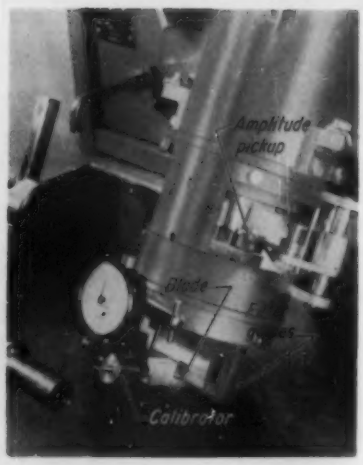
PS . . . Two-part unit consists of ice crusher and storage tray which collects cracked ice. Crusher housing and tray are injection moldings of impact-resistant plastic. Shaded-pole motor bolts to diecasting, which forms one side of the ice chute; other three sides are formed by a one-piece aluminum stamping. "Snoflake" ice crusher is produced by Adams-Pelouze Co, Evanston, Ill.

Focused Energy Cleans Filters

Ultrasonic energy source is put to work at close range. Result: 10-micron and finer high-pressure filters are clean as new in 10 minutes. Simple, accurate tests give constant check of cleaner's efficiency.

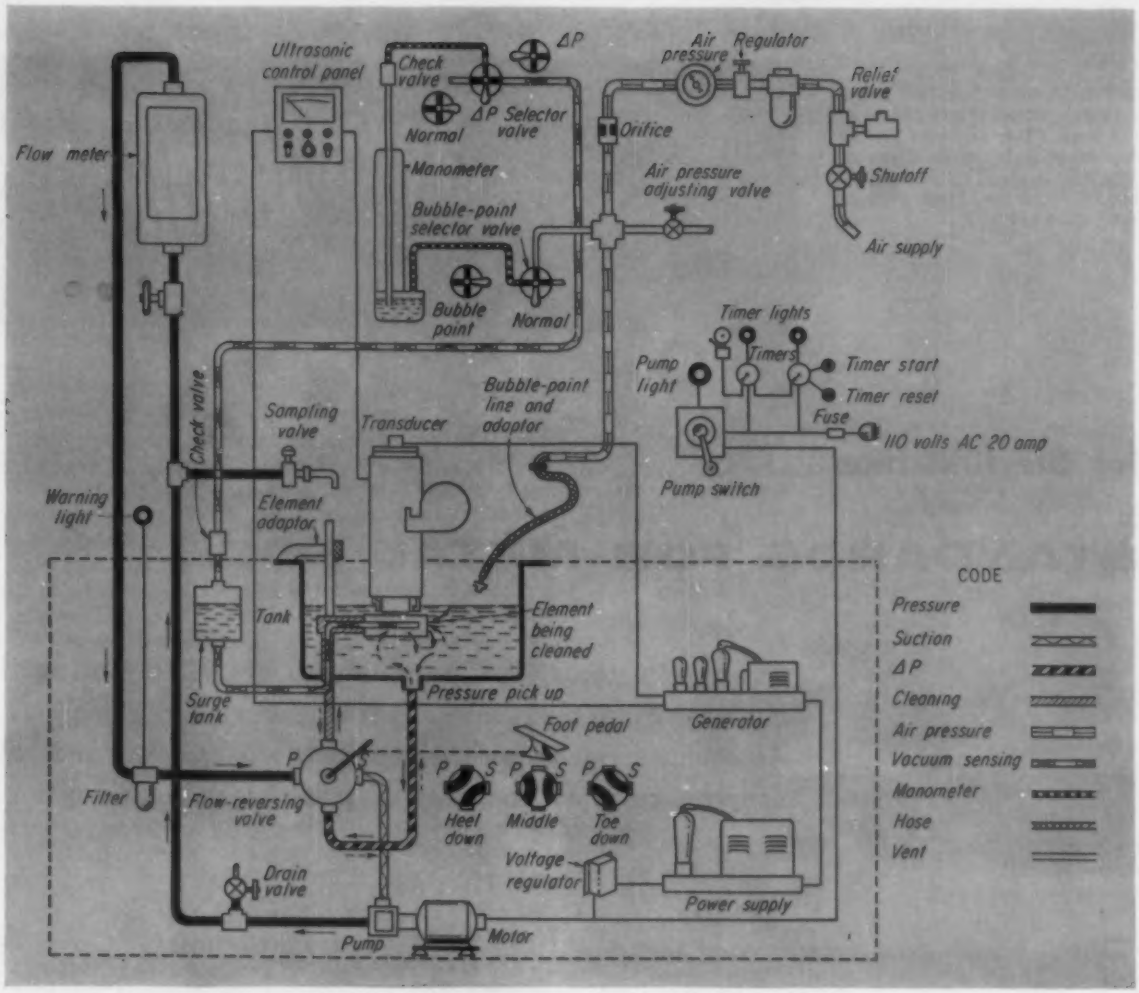






MAGNETOSTRICTIVE TRANSDUCER and cleaning blade are brazed into an integral assembly to prevent mechanical breakdown. Transducer housing is water-filled and aircooled to avoid the complications of a water-cooling system. Adjustable guides, mounted on each side of the blade, insure minimum clearance between the radiating face of the transducer and the filter being cleaned.

A meter, which indicates in microns the double amplitude of the radiating face of the blade, warns operator when amplitude becomes less than 18 microns—the minimum needed for satisfactory cleaning power. The amplitude of the radiating surface (blade) may be measured with an easily installed mechanical calibrator to check and set the amplitude meter on the control panel.



COMBINED CLEANING ACTION of ultrasonic energy and back-flush of solvent takes place simultaneously. Dirty filter elements are mounted on an adaptor on the side of the tank. The adaptor positions and supports the filter and incorporates a pressure pickup inside the filter element. The dirty element is rotated by hand so that the concentrated energy acts upon the entire surface of the element. Solvent is first pumped from the inside to the outside of the element, flushing out the particles as they are loosened by the ultrasonic energy. Flow, which is controlled by a foot-pedal valve, is reversed for the last part of the cleaning cycle to remove any contaminant from the downstream side of the filter element. Ten minutes is sufficient to clean most filters.

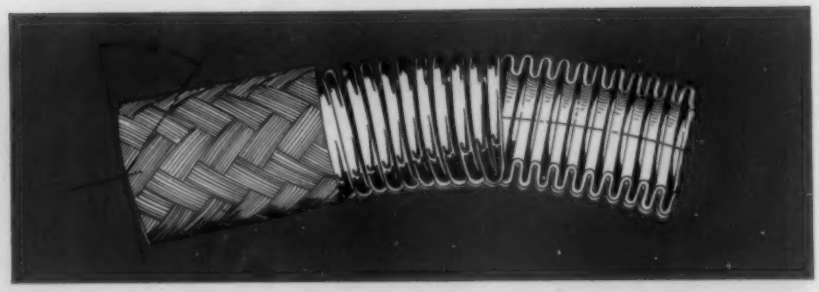
When the solvent flow is reversed, the drop at the outlet of the element is eliminated and the true pressure drop across the mesh and core can be measured by the pressure pickup. This pressure is transmitted through the selector valve to a well-type manometer, where the pressure drop is indicated in inches of water. Cleanliness of filter element can be checked by comparing this measured pressure drop with the corresponding pressure drop for a new filter.

The manometer is protected by a fluid check valve to prevent fluid loss if the selector valve is improperly set.

In addition to the pressure-drop test, a "first bubble" test is made to check the condition of the filter itself. The cleaned element is connected to the bubble-point line and immersed. Air is fed through the bubble-point selector valve to both the manometer and the interior of the filter element. The pressure at which the first continuous stream of bubbles is produced provides a measure of the size of the largest hole in the filter, and thus shows the diameter of the largest particle the filter element will pass.

PS . . . Transducer input is 250 w with a minimum output of 100 w at a frequency of 20,000 ± 500 cps. This 100-w output, concentrated at 2½ x ½-in. transducer blade, is based upon experimental determination that energy densities exceeding 80 w/in.² were no more effective in cleaning, but that lower densities were less effective. Ball-Canitron HIPS (Hyper-Intense Proximal Scanning) filter-element cleaner is produced by Aircraft Porous Media Inc, Glen Cove, NY and Canitron Equipment Corp.

BRAIDED, CORRUGATED TYPE gets its axial burst strength from the braid. This strength can be calculated from tensile strength, size and angle Δ of wire, number of wires used, and average hose diameter.



for the first time . . .

STANDARDS FOR METAL HOSE

Two new methods—now being studied by ASME—introduce uniformity into the choice of corrugated or interlocking hose. An equation rates pressure-type hose; a 5-digit code indexes nonpressure types on bases of material and construction.

L B DONKLE, *engineering manager*
Industial Hose Division
Flexonics Corp, Rock Falls, Ill

Choosing a flexible metal hose for a design frequently involves a survey of manufacturers' catalogs to find such specific information as size, pressure ratings, and temperature limits. Now, for the first time, here are uniform standards for many of the most controversial ratings, simplifying initial choice of a hose type. The final choice, of course, should be made only after consultation with the manufacturer.

These standards have been submitted to Committee on Code for Pressure Piping of ASME (American Society of Mechanical Engineers) and the Flexible Metal Hose and Tubing Manufacturers Association. If accepted, they will become an industry-wide guide.

A hose's primary feature is its ability to move—whether to follow motion, facilitate assembly, correct misalignment, or to absorb and isolate vibration. But that's not the only consideration. Pressure and temperature are important factors, too. You must know how long the hose can transmit fluid without leakage or failure at the temperatures and pressures to be encountered, in the imposed configuration, and with the necessary movement.

But a pressure rating at any temperature is meaningful only if related to some measurable point of failure or deformation. And this failure-pressure reference point will be different for each type of metal hose—whether corrugated or interlocked—depending on its construction.

CORRUGATED HOSE

Braided type

Maximum working pressure rating of the hose assembly under given service conditions depends on: tensile strength of the braided-wire jacket; ability of the corrugated tube (internal-pressure carrier) to resist permanent deformation under pressure while restrained by the braid; operating temperature; pulse or shock loading of the hose; and the method used to attach the end fittings. How these factors influence final pressure rating of hose assembly is expressed in this empirical relationship:

$$P_{rated} = F_T \times F_S \times F_E \times P_{nominal}$$

where F_T, F_S and F_E are factors for temperature, shock or pulse loading, and end-fitting effect, respectively.

Nominal hose pressure $P_{nominal}$ in the equation is, by definition, the lesser of these two quantities: one-third of fluid pressure P_B (calculated) that will burst the external braid in an axial direction; or four-fifths of pressure P_D (determined by test) that will start permanent deformation of the inner corrugated tube.

For a single-layer braided hose, the axial burst pressure obeys this relationship:

$$P_B = \frac{1.57N\,d^2T\sin\Delta}{A}$$

 REPRINTED—Circle P44, inside back cover

where P_B = fluid pressure, psi, that will burst the braid in an axial direction; N = number of braid wires spiraling about hose in one direction; d = diameter of wire, in.; T = effective tensile strength of braid wire, psi; A = total (not annular) cross-sectional area of hose, sq in., based on mean diameter; and Δ = braid angle, deg, measured from a perpendicular to the hose centerline.

This axial-burst-pressure equation is mathematically exact, and makes two major assumptions: (1) all of the axial pressure force is sustained by braid; (2) all the radial pressure force is sustained by the corrugated tube. Typical values for wire tensile strength T are: 40,000 psi for commercial and phosphor bronze; 50,000 for mild steel; and 115,000 for AISI (American Iron and Steel Institute) 300-series stainless steels. Published maximum hose pressure ratings must show values of T assumed.

For a double-braided hose, the same axial-burst equation applies, but the equivalent axial tensile strength of the combined jacket is assumed to be 1.8 times the value for a single-braided hose. This assumption is valid (and conservative) if braid wire can elongate at least 15% (based on a 10-in. length) when tested prior to braiding.

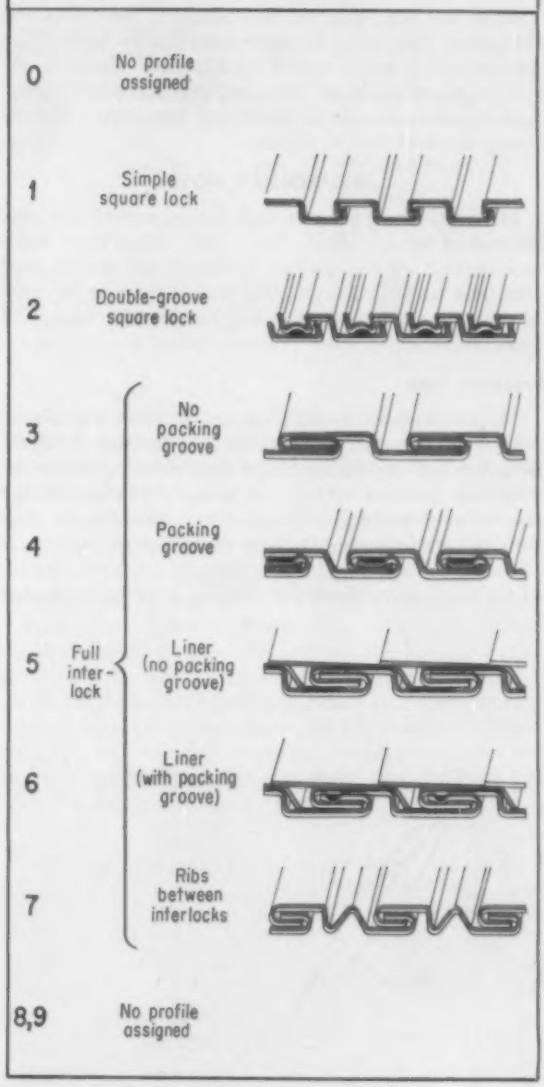
Summarizing: to find $P_{nominal}$ in the hose-assembly rating equation, compare one-third of the final value of hose axial-burst pressure P_B with four-fifths of the radial-deformation pressure P_D determined by test. The lesser of the two will be $P_{nominal}$.

Temperature factor F_T is defined as the ratio of the 0.2% offset yield strength for the hose metal at the elevated (or reduced) temperature, to its yield strength at 70 F. See graph on next page for typical values at elevated temperatures. The factor will increase above 1.0 at lowered temperatures for some metals, but to be conservative use values no greater than 1.0.

Pulse or shock factor F_S cannot be determined by simple calculation, but is an empirical value. Typical values for F_S range from 0.5 (moderate pulses) to 0.2 (severe shock waves). For a manufacturer to estimate probable derating required, he must know peak pressure, rate of pressure rise, number of pulses per second, and expected total operating cycles per year. He will probably recommend a metal hose specially designed for shock or impulse service.

End-fitting factor F_E is 1.0 for a standard brazed or silver-brazed connection, and varies from 0.6 to 2.0 for other attaching methods. For heliarc-welding, the factor is 0.8 to 1.0; atomic-hydrogen welding, 0.6 to 0.8; soft solder, 1.0 to 2.0; and a mechanical coupling, 1.0 to 1.8. The design of the end fitting itself can influence the factor's value, but to a lesser extent.

INTERLOCKED TYPE OF METAL HOSE
gets flexibility from sliding metal components in the interlock. Below are common interlock designs, with code numbers based on table, p 65.



Unbraided, unrestrained type

The maximum pressure rating for unbraided corrugated hose when free to elongate, depends only on permanent axial elongation and temperature. Hose-deformation pressure P_D and end-fitting design are unimportant, because the pressure levels permissable in unbraided corrugated tubing are relatively low—axial deformation will occur before the other factors come into play. Shock factor F_S is left out because pulsing flows are not normally recommended for unbraided hose. The relationship between rated and nominal pressure in a hose assembly is:

$$P_{rated} = F_T \times P_{nominal}$$

The temperature factor F_T is the same as for braided hose. $P_{nominal}$ is that pressure at which permanent elongation (set) equals 0.25% at 70 F, based on this equation:

$$\text{Permanent elongation, \%} = 100 \times (L_F - L_O)/L_O$$

where L_F is final free length of a hose subjected to, and released from, the test pressure; and L_o is the original free length. The test is run at room temperature. The hose

rests on a smooth flat surface with one end free to move. Both hose ends are blanked, but the fixed end has a pressure connection attached. Free length includes active corrugations only—soldered, brazed or clamped corrugations are not included.

Unbraided, restrained type

With this hose, ends are fixed axially to prevent over-all elongation. Can often be rated considerably higher than unrestrained hose for special applications. However, the free length, offset, bend radius, stiffness and other application requirements are so varied and interrelated that no simple standard can be written.

INTERLOCKED HOSE

Interlocked hose is made both for pressurized and nonpressurized service. Both kinds have temperature limits that depend on the packing materials and metals used (see table below). But only the pressurized type has pressure-temperature standards similar to those for corrugated hose.

Pressure type

Maximum pressure rating for an assembly depends on hose burst strength, temperature, and leakage. Axial deformation and end-fitting design are not considered in the maximum pressure rating, but some end-fitting leakage may occur if packing is damaged by welding or brazing. This rating relationship for hose assemblies applies:

$$P_{rated} = F_T \times P_{nominal}$$

where temperature factor F_T is the same as for corrugated hose, but $P_{nominal}$ is defined as the lesser of these two values: one-third the burst pressure at 70 F; or one-third the minimum weep (leakage) pressure.

Burst pressure will vary from test to test; the value selected can be an average value but must be at least 15-20% higher than the minimum burst pressure. Minimum weep pressure is the lowest at which there is no continuous leakage of water (or SAE 10 oil) at 70 F through the hose convolutions. (Continuous leakage means that drops of fluid form on the outside of a hose bent to its minimum radius within one minute). However, most interlocking hose will burst before leaking.

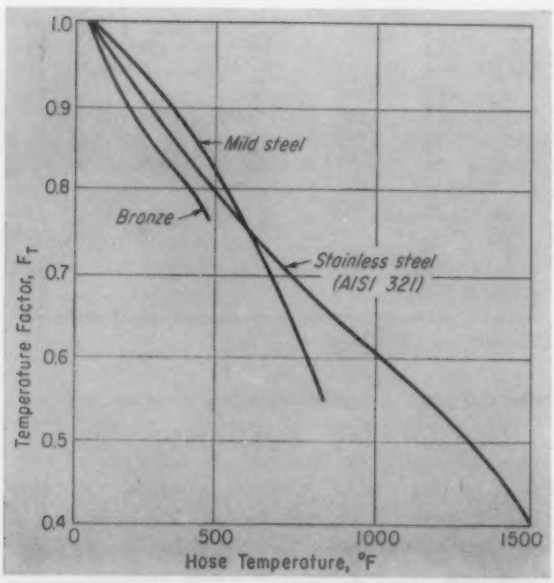
Nonpressure type

This type is not classified by pressure but by major construction features. A five-digit number code is sufficient to cover the important details:

first digit—type of interlock
second digit—thickness range of metal strip
third digit—metal used
fourth digit—packing
fifth digit—jacket or covering

To designate an interlocked hose with the five-digit method, look up the key number for each digit in the classification table on this page. Here are some examples, the first of which is worked out in detail:

• Fully interlocked lightweight galvanized steel ventilating ducting will be classified 31100. The "3" means fully interlocked without a packing groove; the first "1" is light-gage metal—0.008 to 0.015 in. thick; the second "1" is galvanized steel; the first "0" means no packing; and



TEMPERATURE FACTORS for three hose metals (max rated pressure at elevated temp = $F_T \times$ max rated pressure at 70 F)

TEMPERATURE LIMITS OF HOSE MATERIALS

(recommended)

Material	Max temp, °F
Aluminum	600
Asbestos packing, grade:	
commercial	400
Underwriters	450
A	550
AA	600
AAA	750
AAAA	900
Brazing alloys:	
copper base	850
silver (AMS 4770)	750
silver (AMS 4772)	850
Brass	450
Bronze	450
Cotton-cord packing	200
Galvanizing	450
Monel	800
Neoprene packing	250
Solder, soft	
60-40% lead-tin	250
95-5% lead-tin	350
Steel, mild	850
Steel, stainless AISI type:	
302, 304	850
316	850
316 ELC	1500
321, 347	1500

5-DIGIT CLASSIFICATION OF INTERLOCKED HOSE

Category→	1st digit INTERLOCK	2nd digit THICKNESS, in.	3rd digit METAL	4th digit PACKING	5th digit COVERING
Code:					
0	.....	<0.008	bright steel	none	none
1	simple square lock	0.008–0.015	galvanized steel	asbestos	wire braid
2	double-groove square lock	0.016–0.025	stainless: AISI-400	cotton	thermoplastic (PVC, etc.)
3	full; no packing groove	0.026–0.035	AISI-300	neoprene or Buna N	synthetic rubber
4	full; packing groove	0.036–0.045	combined (code 1 and 3)	natural rubber	asbestos or fiberglass
5	full; no packing groove; liner	0.046–0.055	brass	copper	reinforced synthetic rubber
6	full; packing groove; liner	0.056–0.065	bronze	.....	.....
7	full; ribbed	0.066–0.075	aluminum	.....	.....
8	.....	0.076–0.085	copper-nickel alloys	.....	.....
9	other	>0.085	other	other	other

the last "0" means no covering. If a synthetic rubber cover were desired, last digit would become 3.

- Packed, galvanized-steel, abrasion-resistant, heavy-weight tubing with stainless steel liner—62410.
- Fully interlocked bronze capillary casing—31600.

To distinguish between corrugated and interlocked hose, type numbers are included in the classification. Type I is corrugated, braided; Type II is corrugated, unbraided, unrestrained; Type III is interlocked, pressurized; and Type IV is interlocked, nonpressurized. The first example of the preceding three is completely defined as: Type IV, class 31100, ventilating ducting.

DEVIATIONS FROM THE STANDARD

Higher-than-standard pressures and temperatures are allowed in special circumstances if the manufacturer knows that life and reliability will be adequate. Here are typical circumstances.

Intermittent temperatures—If the hose is at peak temperature only part of the time, then hose-deterioration rate will be slower. This is important when failure is related to excessive oxidation, carburization, graphitization, diffusion of injurious gas into the hose metal, metallurgical phase changes, or other time-dependent changes. A somewhat higher peak temperature can therefore be recommended by the hose manufacturer.

Favorable environment—If the atmosphere (or fluid) is essentially noncorrosive, even at high temperatures, then temperature-induced metallurgical phase changes in the hose metal are sometimes tolerable. For example, an AISI type-304 stainless steel hose suffers from carbide precipitation at grain boundaries at 1200 F—usually undesirable because the metal loses its resistance to corrosion. But in a noncorrosive environment, the hose will not deteriorate, and can be rated at the high temperature.

Temperature gradient—The limiting temperature is not always the highest measured temperature, because cooler portions of the hose cross-section can add strength to the whole. An uninsulated hose will have a slight temperature gradient from inside to outside, and the fluid temperature can safely be somewhat above the maximum service temperature of the hose. An insulated hose, however, has negligible temperature gradient, and fluid must be at rated temperature.

Tube-wall thickness—A thick-walled hose exposed to a corrosive environment will corrode at the same rate as one with a thin wall. But for the same depth of penetration, the thick wall retains more of its original mechanical strength. Therefore, in corrosive environments, thick-walled hose can be rated for slightly higher temperatures, or for longer service at the same temperatures.

For REPRINT of above article, just check P44 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Both performance and design of metal hose have been covered in these previous articles:

Metal Hose, Nov 11 '57, p 87, concisely describes just what constitutes a flexible hose, summarizes selection problems, gives maximum pressure limits and minimum bend radii for typical types.

Pressure Losses in Flexible Metal Tubing, Apr '56, p 223, tabulates coefficient of fluid friction for concentric and helical corrugated tubing, gives pressure-flow nomograph based on water.

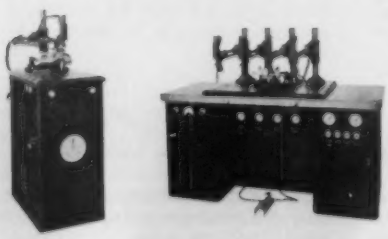
Modern Fluids for Power and Control, Jan 18 '60, p 56, analyzes performance of power fluids such as oil, water, air, esters, silicones and glycols, and shows compatibility with typical packing materials.

Better Ratings for Fluid-control Valves, June 22 '59, shows how the pressure-rating problem can be solved for a valve by defining six levels of pressure from min to burst.

COMING: Mr. Donkle will offer a step-by-step technique for designing with flexible metal hose. This article will include discussions of: shock and pulse loading; vibration, flexure, torsion and pressure-cycling fatigue; flexibility; and corrosion.

...and OMARK-GRAHAM® stud welding system will increase speed, lower costs of your fastenings

Whether it's a tiny stud to be fastened to aluminum hearing aid-eyeglasses or a sturdy, specially-designed functional part for an automatic transmission, there's an OMARK-GRAHAM stud and welder to do the job.



Two of the models of OMARK-GRAHAM stud welders available for production line welding without burn-through or distortion.

Weld To Many Metals Without Burn-Through Or Distortion

You can lower your fastening costs and speed up production of metal fabrication with OMARK-GRAHAM stud welding system. Fasten studs of any design to steel, stainless steel, copper, aluminum or zinc.

The OMARK-GRAHAM stud welding system can be used on finished products without harming the finished side whether it is plated, painted or plastic coated. This fastening method is being used by manufacturers in every branch of industry: aircraft, electronics, household goods and automotive. Saves money in design and production; can replace forming, casting, soldering, brazing operations.

Investigate this product-improving, cost-lowering fastening method now. Our sales and engineering departments will help you work out the details that will save you money.

Wide Range Of Standard And Custom-Designed Welders And Studs

Whatever your fastening requirements, OMARK-GRAHAM offers a machine and studs that will do the job. Machines can be automatic or manually operated; single welding gun or multiple. Studs can be made from many types of metal in many shapes or sizes.

For More Information, Write, Wire or Telephone:

OMARK Industries, Inc.

1015 Reading Road, Cincinnati 41, Ohio, PRinceton 1-3131.
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CIRCLE 66 ON READER SERVICE CARD

unique chart maps . . .

RESILIENCE MODULUS

Multipurpose graph simultaneously measures other properties of the material, and compares it with other materials.

DR KARL W MAIER, *scientific advisor*
Olin Mathieson Chemical Corp
New Haven, Conn

Symbols

S = stress at elastic limit in tension, compression or shear, psi

e = elastic strain in tension or compression, in. per in.

E = modulus of elasticity, psi ($E = S/e$)

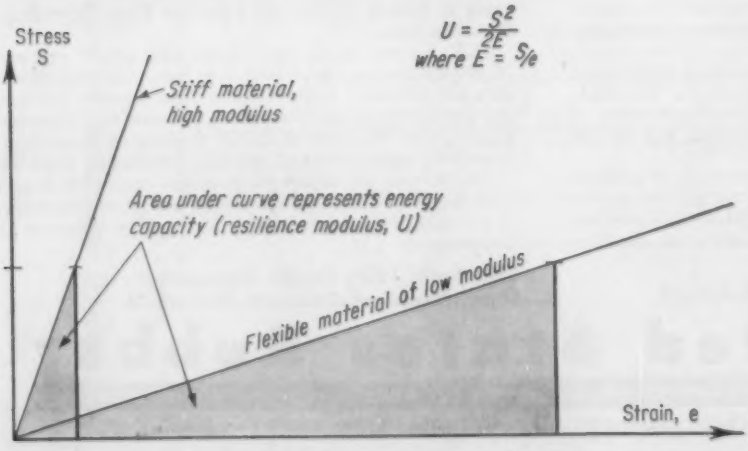
G = shear modulus, psi

U = resilience modulus, in.-lb/in.^{3} ($U = S^2/2E$ for tension or compression; $U = G^2/2E$ for shear)

Resilience modulus, the amount of mechanical energy that a material can store per unit of volume, can be found from a simple formula (see list of symbols). This method, however, measures only one property of the material. The chart on the continuing page not only supplies quick resilience-answers, but also allows a simultaneous and broader comparison with other materials. Stress, strain, elasticity modulus and resilience modulus are all combined in this one chart. Only two values need be known; the chart supplies the other two.

EXAMPLE: Under max stress of 240,000 psi, with elasticity modulus of 30,000,000 psi, steel has a strain value of 0.008 and resilience modulus of 960 in.-lb/in.^{3}

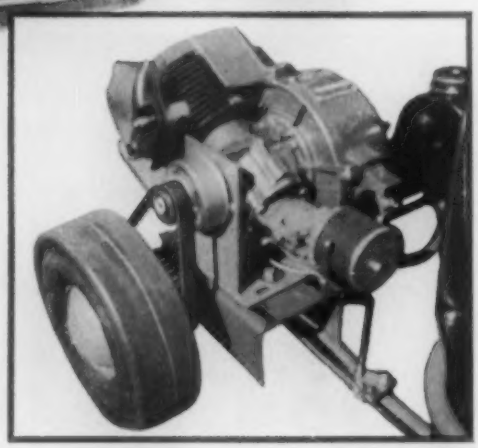
continued on page 69



STIFF MATERIAL VS FLEXIBLE MATERIAL. Graph shows that even with a low elasticity modulus, a material can still have a greater resilience modulus than a much stiffer substance. It would therefore fail sooner, in accordance with the postulate that failure point occurs in an object when the stored energy exceeds a critical value.

US RUBBER **PowerGrip** "TIMING" BELTS from the Power Unlimited complete belt line

Even the youngsters are making time with the U.S. PowerGrip "Timing" Belt



Howard Industries, Inc. (Sumter, S. C.) use the U. S. PowerGrip "Timing"® Belt to get perfect transmission response on the Go-Karts they manufacture.

Says Howard E. Short, president, "This car is being raced with gratifying results by children and adults. The U. S. PowerGrip 'Timing' Belt provides positive transmission of power. Our engine is a 2½ h.p., 2-cycle chain saw engine turning up at 6200 r.p.m.

"U. S. PowerGrip 'Timing' Belt drives made it possible to economically convert this motor for installation in the Go-Kart. Since 'Timing' Belts are fixed drives, they need no maintenance or adjustment and they whiz the Go-Kart along at speeds of 35 to 60 miles per hour, depending on the drive ratio."

U. S. PowerGrip "Timing" Belts with speeds ranging to 16,000 r.p.m. and up to 1000 h.p. have made possible not only the efficiency of the Go-Kart, but literally the design and production of hundreds of appliances and equipment, ranging from sensitive electronic devices, office machinery, household equipment and gigantic production machinery.

One way to get expert transmission counsel is from the U. S. Rubber Distributor. He's your best on-the-spot source of technical aid, quick delivery and quality industrial rubber products.

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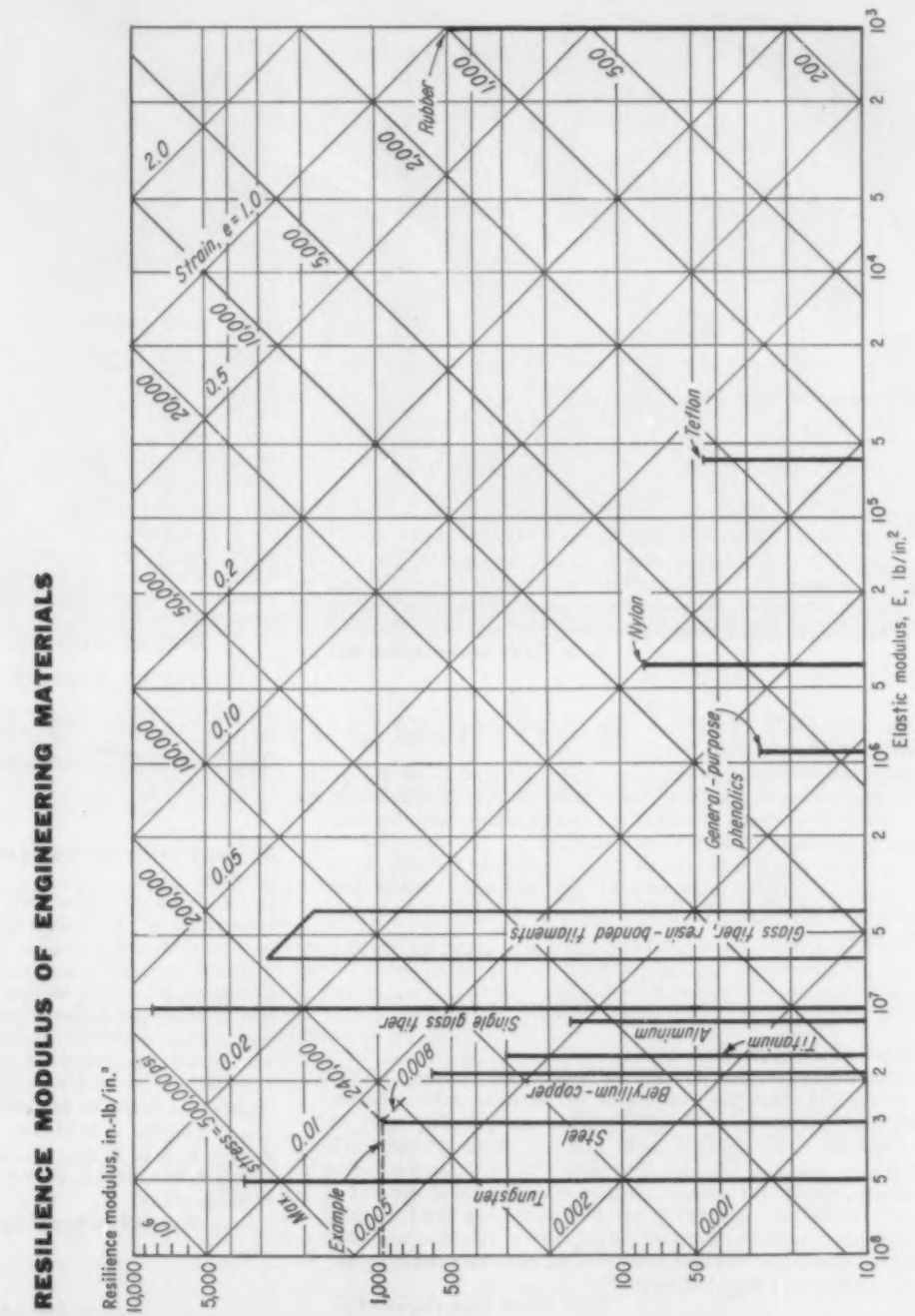
RESILIENCE MODULUS continued

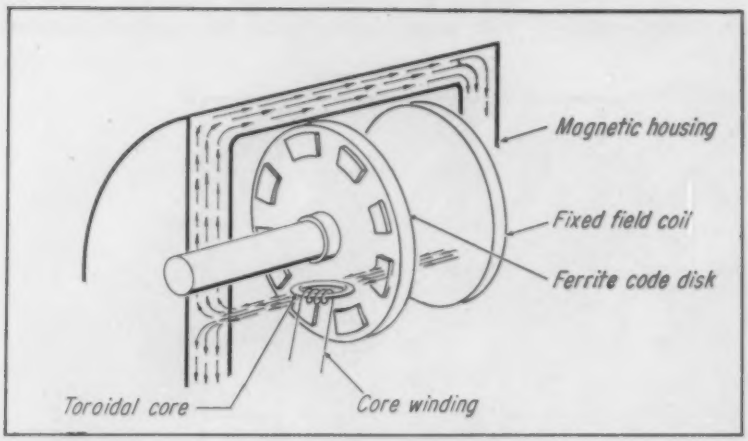
The chart can also be looked upon as a map of "unexplored territory" in the range of properties considered, showing areas where materials have yet to be discovered.

Glass-reinforced plastics, for example, occupy a space on the chart that was blank before they were developed.

Eleven materials have been plotted as examples to show how the chart quickly reveals where a material falls on the resilience-modulus "spectrum." There is a wide range of elastic moduli from rubber to tungsten.



SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Magnetic shaft-position-to-digital encoders . . .

generate digital signals representing input-shaft position by altering magnetic state of ferrite readout cores in accordance with coded pattern cut into surface of ferrite disk driven by input shaft. Shaft-position-to-digital encoders embodying this technique are said to permit higher rotation speeds and to have potential life exceeding 20,000 hr. Magnetic technique has been successfully applied to 7-, 13-, 17-, and 19-bit encoders capable of 128 counts per input shaft revolution. Input-shaft speeds as high as 10,000 rpm can be accommodated by 7-bit encoder. Speeds of 3000 rpm are possible with higher capacity units. Encoders can be supplied with wide range of digital codes. Operating temperature is —4 to 212 F. Prices range from about $770 to $1900. Delivery, 90 days. **Librascope Div, General Precision Inc, Glendale, Calif.**

Circle 300 on Reader Service Card

Reversible potting compound . . .

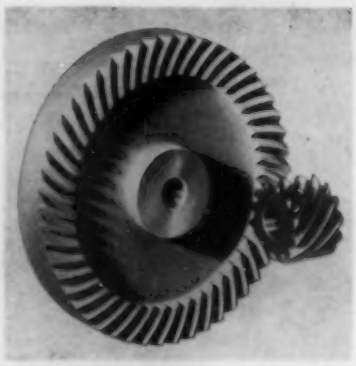
cures at room temperatures and dissolves when potted unit is placed in liquid solvent. When cured, compound has appearance of plaster of paris. Dissolving action is so rapid that it is possible to direct stream of solvent at a specific area without dissolving entire unit. Thermal conductivity is 0.0008 cal/sec-cm²-°C per cm. Specific gravity is 1.2. Temperature range is from —65 to 250 F. Said to be especially useful for encapsulating circuitry containing components of high unit cost. Sample kits, with 2 lb of compound and solvent, are $6. **Video Instruments Inc, 3002 Pennsylvania Ave, Santa Monica, Calif.**

Circle 301 on Reader Service Card

Adhesive-backed aluminum foil . . .

can be bonded permanently to plastics, plywood and other wood products. When bonded integrally to wood or plastic products, coated foil serves as moisture barrier, decorative element, base for paint, as a light reflector, strengthening agent or disperser of heat. Bonding is accomplished under heat and pressure, usually in a hot press. Offered in gages down to 0.001 and widths up to 50 in. Costs vary according to thickness and adhesive-coating. For example, 0.001-in. thick foil, coated one side, is $30.75 per 1000 sq ft; coated two sides, $42.75 per 1000 sq ft. Foil 0.005 in. thick costs $70.30 per 1000 sq ft coated one side; $82.30 per 1000 sq ft coated two sides. Available in production quantities in standard sheet sizes for immediate delivery. **Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.**

Circle 302 on Reader Service Card



Skew-axis gears . . .

are applicable through ratio range from 3:1 to 400:1. Depending on size and application, gears may be hobbed, cast of metal or plastic, or compacted of sintered metal. Pinions may be rolled, milled, chased or, on higher numbers of teeth, hobbed. Gears available in 1 to 16 in. OD. Gears are said to be low in cost, yet to maintain high degree of insensitivity to mounting errors. Delivery, after prototype approval, 4 to 8 wk. **Spiroid Div, Illinois Tool Works, 2501 N Keeler Ave, Chicago 39.**

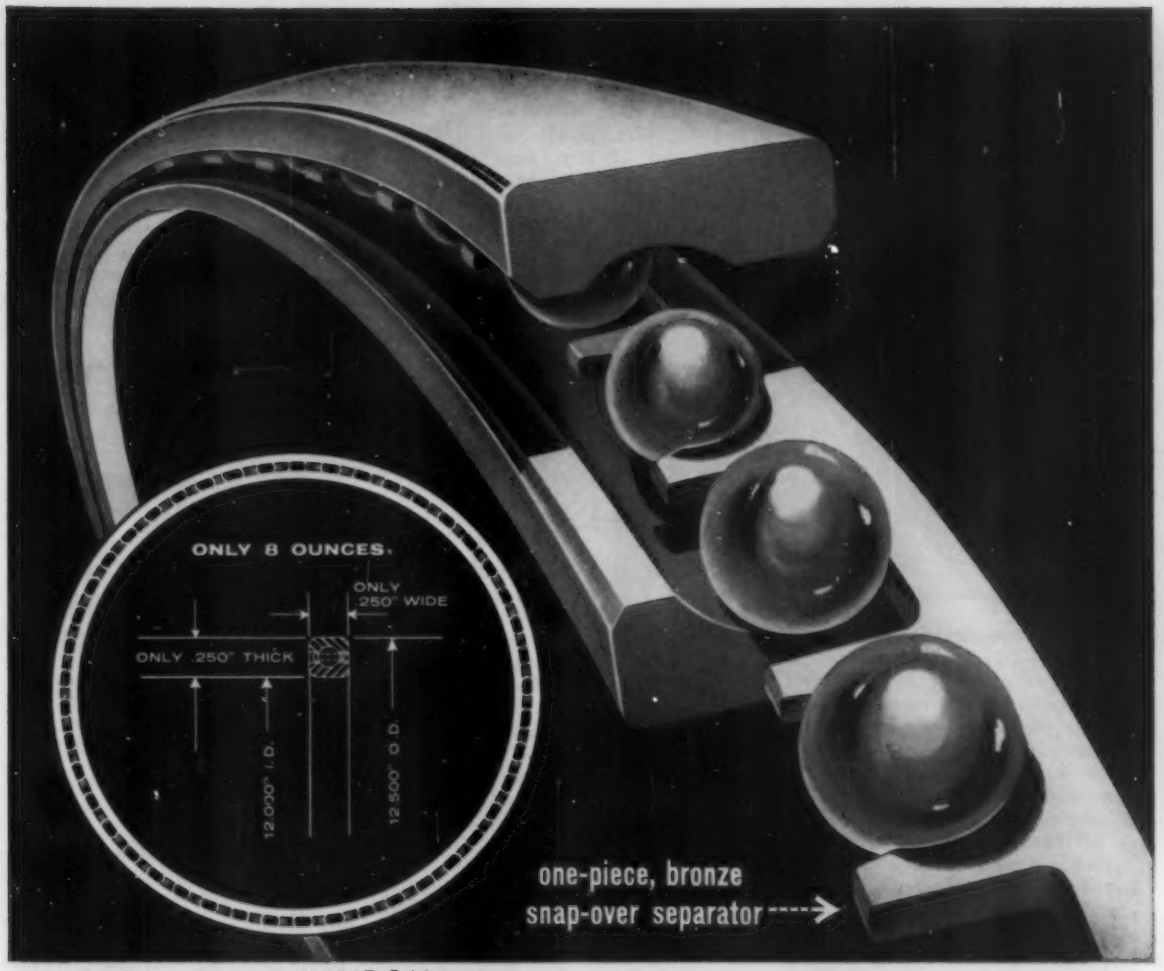
Circle 303 on Reader Service Card

Pickups with spring-loaded probes . . .

permit choice of conical, ball, roller or other probe ends and various spring compressions. Variable-permeance transducer is used in operations where probe cannot be coupled to moving member, such as cam following and automatic gaging. Can also measure thickness, roundness, taper and surface smoothness of production parts. Four models are available in rated displacement ranges of 0.25, 0.50, 1 and 2 in. Prices start at $147 each. Standard delivery, stock to 30 days. **Crescent Engineering & Research Co, 5440 N Peck Rd, El Monte, Calif.**

Circle 304 on Reader Service Card

continued on page 72



News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

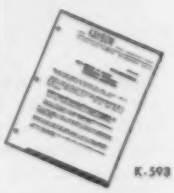
Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

Save on bearing cross-section and weight — Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.



K-593

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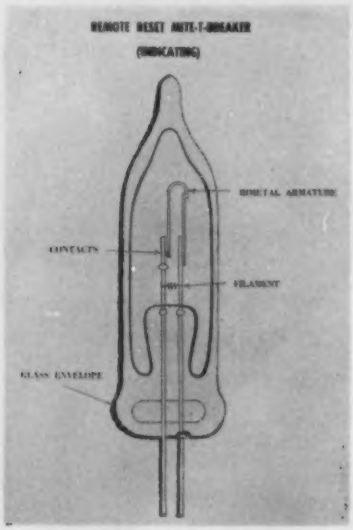
All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings • 4-Point Contact Ball Bearing



Subminiature circuit breaker

with built-in indicator light is for use in low-voltage electronic systems. Remote reset-circuit protector is vacuum sealed in glass envelope, and contains tungsten filament that becomes incandescent when circuit is broken. With circuit open, filament produces sufficient light to act as indicating device and opens breaker for up to 100 hr. Filament is charged by 200-milliamp current. Circuit breaker can be operated at 6 to 24 v ac/dc. Available in range that holds from 1 to 5 amp and trips at double the amperage. Device measures 1¼ in. long and ¼ in. dia. **Sylvania Electric Products Inc, 730 Third Ave, New York 17.**

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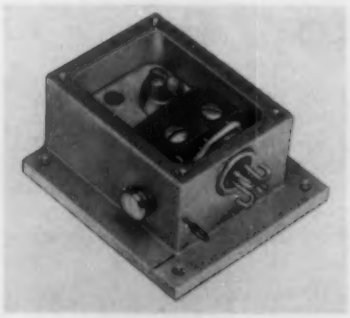
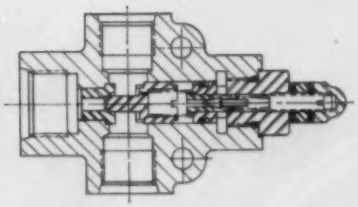


Subminiature timer . . .

with time-delay range of 1 to 60 sec is said to withstand shock of 300 g with up to 20 millisec dwell and 5 millisec rise. Over-all accuracy is reported to be 2%. Timer consists of spring-wound clock-escapement mechanism that actuates SPDT 5-amp switch. Clock is mechanically wound and held in cocked position by pull pin. When pull pin is removed, switch is actuated after preset delay. Operates in ambient temperatures of −60 to 250 F. Withstands acceleration of 60 g along each of three major axes and vibration ±10 g sinoidal from 10 to 2000 cps. Timer fits into 1 cu in. **Auto-Timer Div, Sloan Co, 7704 San Fernando Rd, Sun Valley, Calif.**

Circle 306 on Reader Service Card



Pilot-operated relief valve . . .

has capacity of 30 gpm in offset mounting and 20 gpm when mounted in-line. Pressure adjustment range is 250 to 3000 psi. Pressure rise between cracking or opening of relief to full flow at max rated capacity and pressure is 6%. **Parker Hydraulics Div, Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.**

Circle 307 on Reader Service Card

Painted aluminum coil . . .

from 2 to 66 in. wide, in 0.006 to 0.064 gages, is available in a variety of colors in various types of paints. Coil can be coated on either one or both sides. Product is adaptable to bending, brake and roll forming, crimping, blanking or flattening without damaging the finish. **Kaiser Aluminum & Chemical Corp, Kaiser Center, 300 Lakeside Dr, Oakland 12, Calif.**

Circle 308 on Reader Service Card

Vane-type spark arrestor . . .

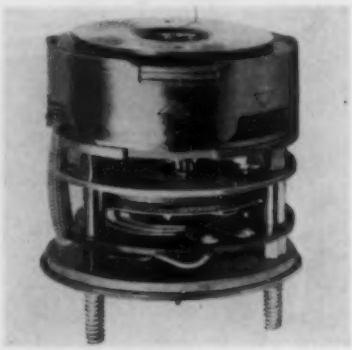
adaptable to mobile and stationary internal combustion engines, employs centrifugal-action principle without using moving parts. As exhaust stream flows through unit, stationary vane imparts spinning action to airflow. Standard models are available in aluminized steel with cast, ductile iron vane. Offered in four sizes to fit engines from 150 to 1200 cu in. displacement. **Air-Maze Corp, 25000 Miles Rd, Cleveland 28.**

Circle 309 on Reader Service Card

Adjustable-speed ac drives . . .

are integral units rated from ¼ to 100 hp. Larger drives with separate motor mounted on bedplate are offered up to 700 hp liquid-cooled. Standard excitation and regulator control for aircooled drives up to 30 hp measures 9¾ x 8¼ x 24¼ in; for higher hp units, control is only silghtly larger. Control units provide speed regulation said to be accurate within 2% of top speed. **Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.**

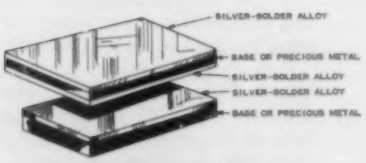
Circle 310 on Reader Service Card



Stepping devices . . .

perform high-speed sequencing, pulse control and switching functions. Also can replace solenoid or relay-actuated devices in many cases. Stepping action is achieved magnetically, at rates up to 2400 pulses per min. at 24 v dc. With power off, switches are magnetically locked. Printed circuit rotary stepper switches contain up to 30 positions on single deck and each pulse cycle advances switches one position. Units can be factory-set to produce output pulses in any desired proportion to input. Rotary and precision gated stepper switches and precision sequencers are included in line. Conform to specifications of MIL-E-5272C. **A W Haydon Co, 232 N Elm St, Waterbury, Conn.**

Circle 311 on Reader Service Card



Solder-clad base metals . . .

or precious metals are now available in sheet, strip and foil. Composites of silver or noble-metal solder alloys are used in precladding operation to simplify assembly of parts. Can be clad on one or both sides of any base or precious metal in strip form. Composites other than stainless

continued on page 74

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LOGAN HAS IT!

RIGHT PRICE

TOP QUALITY

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in hydraulic power devices

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- ☐ 200-4 AND 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
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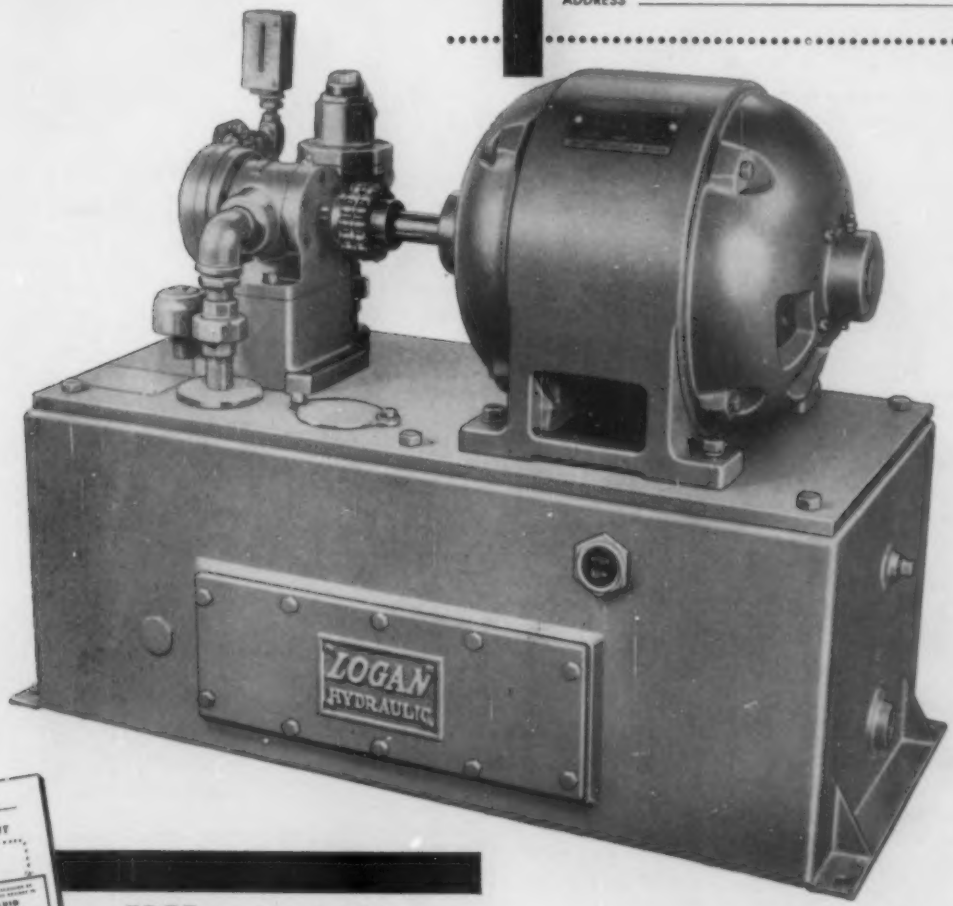


ILLUSTRATED—LOGAN MODEL 6031 HYDRAULIC POWER UNIT

FREE **SEND FOR YOUR COPY OF THE LOGAN "CIRCUIT RIDER"**

A 32-page manual on fluid power circuits (fifth edition) completely revised to present current engineering trends.

MEMBERS: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

CIRCLE 73 ON READER SERVICE CARD 73

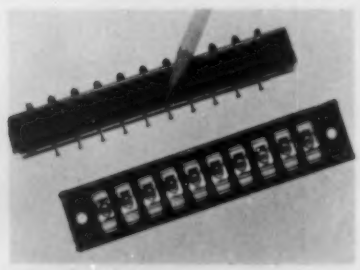
steels can be fabricated to 0.5 in. thick and 20 in. wide. Solder-clad stainless steel max gage is about 0.062 in. thick and 10 to 12 in. wide. Max and min limits depend on cladding ratios, solder and base-metal selection. Cladding ratios range from 5/95 to 70/30 for single-clad material; 5/90/5 to 35/30/35 for double-clad material. **General Plate Products Group, Texas Instruments Inc, Metals & Controls Div, 34 Forest St, Attleboro, Mass.**

Circle 312 on Reader Service Card

½-w photoconductive cells . . .

are said to combine relatively high dissipation ratings with ¼ in. dia, hermetically sealed package. Two standard types, cadmium selenide and cadmium sulphide, are available. Average continuous power ratings for cells are 0.5 and 0.25 with optional bracket mounted on heat sink and without, respectively. Cells are rated 250 v dc or peak ac. Peak spectral responses for cadmium sulphide and cadmium selenide units are 5500 (same as human eye) and 6900 (near infrared range). Prices range from $1.25 to $4, depending on quantity. **Clairex Corp, 19 W 26 St, New York City.**

Circle 313 on Reader Service Card



Rows of feed-through lugs . . .

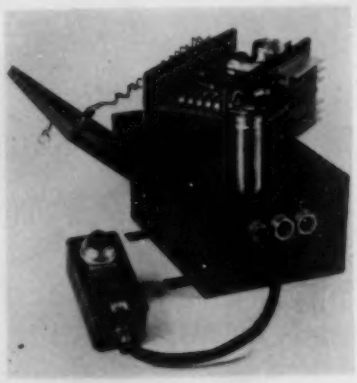
have been added to bottom of vertical-entry terminal block to increase application versatility. One cavity accommodates four terminals. Up to 40 connections can be made with one block and adjacent terminals can be bussed together with special connectors. Block measures 5 x 1 1/16 x ¾ in. Terminal lugs are available in bulk or in reels of 1 to 3000 for automatic assembly equipment. Block sockets are gold-plated. Installation is made by inserting lug in block and tightening screw. Once connection is made, it takes 100 lb of pressure to pull lug from its socket. **Twin Lock Inc, 1024 W Hillcrest Blvd, Inglewood, Calif.**

Circle 314 on Reader Service Card

Subminiature synchronous motor . . .

operates at 115 v with max power input of 2½ w, speed of 3000 rpm and power factor of 0.9. Rotation is reversible. Measures 1 in. dia and 1 11/16 in. long; weighs 1.7 oz. This 400-cps motor meets requirements of MIL-E-5272B for temperature, altitude, vibration and shock. Sells for under $40; 1-wk delivery. **Waltham Precision Instrument Co, 221 Crescent St, Waltham 54, Mass.**

Circle 315 on Reader Service Card



Dc motor-speed control . . .

is said to provide constant speed regardless of load variation of any dc shunt motor up to 5 hp. Can also be adapted for dc motors of larger sizes. Utilizes silicon-controlled rectifiers and magnetic triggers. **ACF Electronics Div, ACF Industries Inc, 800 N Pitt St, Alexandria, Va.**

Circle 316 on Reader Service Card

Variable-speed pulleys . . .

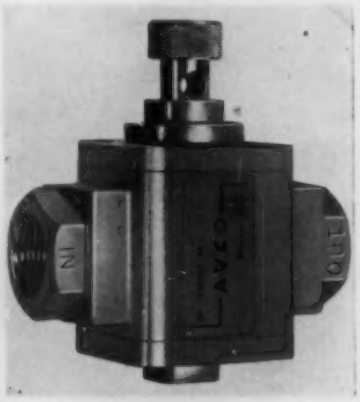
utilize smaller top width belts and sheaves. Six available sizes range from fhp to 5 hp, with speed ratios up to 4:1. Can be installed on old or new equipment. **Lovejoy Flexible Coupling Co, 4856 W Lake St, Chicago 44.**

Circle 317 on Reader Service Card

Double-vane-type hydraulic pumps . . .

provide one power source for two separate hydraulic circuits or greater volume through combined delivery of both sections. For normal operation at speeds to 2000 rpm and pressures to 2000 psi. Variety of ring sizes in each section of double pump offers user selection of capacities from 8 gpm in small section to 77 gpm in large section at rated speed and pressure. All five models of double pumps ultilize replaceable pumping cartridge. **Vickers Inc, Detroit 32.**

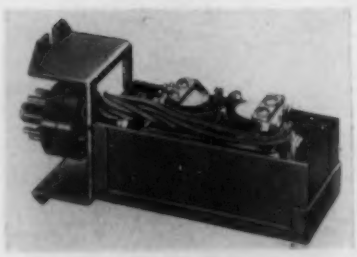
Circle 318 on Reader Service Card



Shutoff and bleed valve . . .

for air or hydraulic supply lines has aluminum alloy body. Quarter-turn of thumb nut stops line pressure and automatically bleeds off pressure on downstream side. Hole in valve stem permits padlocking in closed position when line is to be down for extended period. Pressure range is 0 to 150 psi. Presently available for ⅜, ½, and ¾ in. air or hydraulic lines. **Air Valves Co, 24581 Groesbeck Hwy, Warren, Mich.**

Circle 319 on Reader Service Card



Latch-in relay . . .

with plug-in mounting and hold-down clamp is made of two miniature telephone-type relays in common support frame. Armatures of two relays are mechanically interlocked. When one armature is energized, it releases the other and becomes latched-in. Relays can be supplied for different operating voltages or currents and with different contact arrangements. Available for dc continuous or intermit-

continued on page 76

IBM 1620 *data processing system*

...the most powerful engineering computer in its low price class

The new IBM 1620 is a desk-size engineering computer that offers you more computing ability per dollar than any system in its price class.

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CIRCLE 75 ON READER SERVICE CARD 75

How United States Testing Company helps

STOP TROUBLE BEFORE IT STARTS

Spotting "bugs" in new products and eliminating them before marketing... that's how United States Testing Company saves clients thousands of dollars and priceless good will. Take the case of the new movie camera ready for the mass market... our test film went through without trouble, until a special spliced section jammed the sprockets and stripped a gear.

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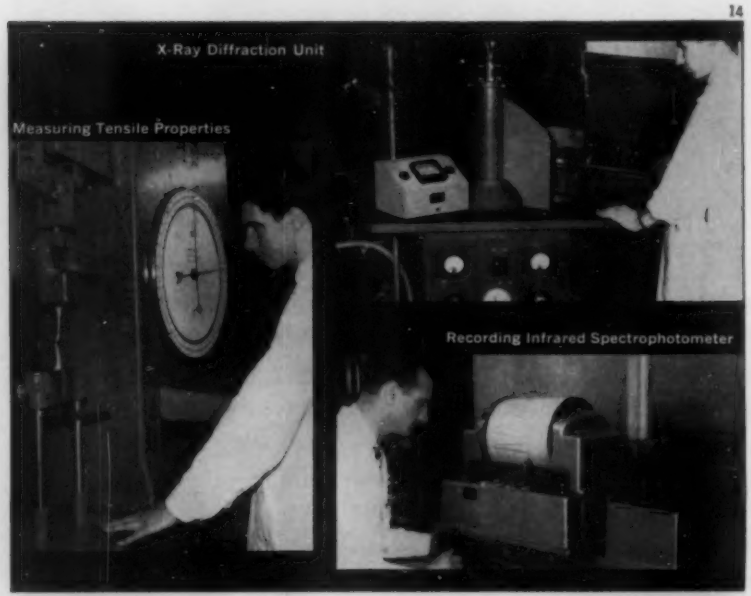

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tent duty and for ac intermittent duty. Supplied with 8-, 12- or 20-pin plug. Overall dimensions are $4\frac{31}{32}$ x $2\frac{1}{16}$ x $1\frac{1}{16}$ in. Magnecraft Electric Co, 3350Y W Grand Ave, Chicago 51.

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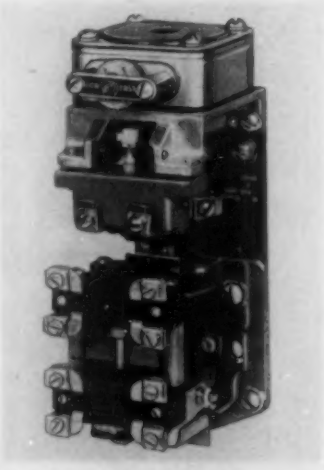

Snap-switch interlocks . . .

are furnished on timers with adjustable timing range of up to 3 min. Can be furnished with one or two SPDT instantaneous interlocks. Both timer head and magnet assembly are front-removable. Square D Co, 4041 N Richard St, Milwaukee 12.

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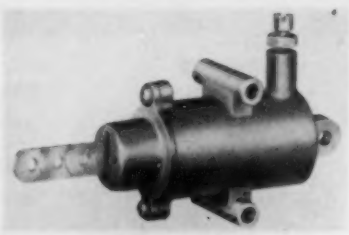

Dashpots . . .

set up retarding action for any mechanical device. Standard models have piston travel of $1\frac{7}{16}$ in. Adjustable needle valve affects resistance exerted by rod. Rod is available with or without return spring. Body is die-cast. Nuarc Co Inc, 4110 W Grand Ave, Chicago 51.

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Rotary index tables . . .

offer slow start and slow stop on each index. Powered by fhp electric motor, rotary air motor or hydraulic motor. Locking and indexing construction, however, is mechanical. The 40:1 ratio on worm gear drive rotates cam giving positive lock on 180° of rotation. Indexes up to 5000

continued on page 81

BARBER-GREENE specifies INTERNATIONAL Power

for world's leading line of asphalt plants!

Report from Guy Banister,
Chief Technical Engineer,
Barber-Greene Co., Aurora, Ill.

"We standardized on International diesels for Barber-Greene Continuous Mix Asphalt Plants in 1947, and owners' reports prove we made an excellent choice."

"For 30 years Barber-Greene Continuous Plants have played a major role in making asphalt paving the world's most used road surface. Since the 30's road builders have been able to produce a controlled high-quality mix in high volume at low cost, and that calls for *efficient power.*

"Because the whole paving operation depends on our plants for asphalt production, plant downtime can run as high as $5,000 hourly. And since engines on the plants operate under continuous load 8 to 10 hours daily—that calls for *dependable power.*

"Since Barber-Greene Continuous Mix Plants are highly mobile—often moving to 6 or 8 jobs in a season—that calls for engines supported by an *excellent parts and service organization.*

"International diesel engines meet Barber-Greene standards for efficiency, dependability, and parts and service support. That's why we standardized on IH power for these plants. Performance records over the past 13 years show that our customers, too, are satisfied International users."

You, too, can build into your products the advantages of International power. Check the complete International engine line—32 carbureted and diesel models from 16.8 to 385 max. hp. You'll like the one common feature of all 32 engines: fastest payback power for users. Just call or write International Harvester Co., Engine Sales Department, Construction Equipment Division, Melrose Park, Ill.

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Design of high-speed precision machinery often calls for bearings which offer the utmost in load capacity, "hot hardness", dimensional stability. Each machine presents its own exacting requirements.

Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

- **A broad range of types and sizes, numbered in the thousands**
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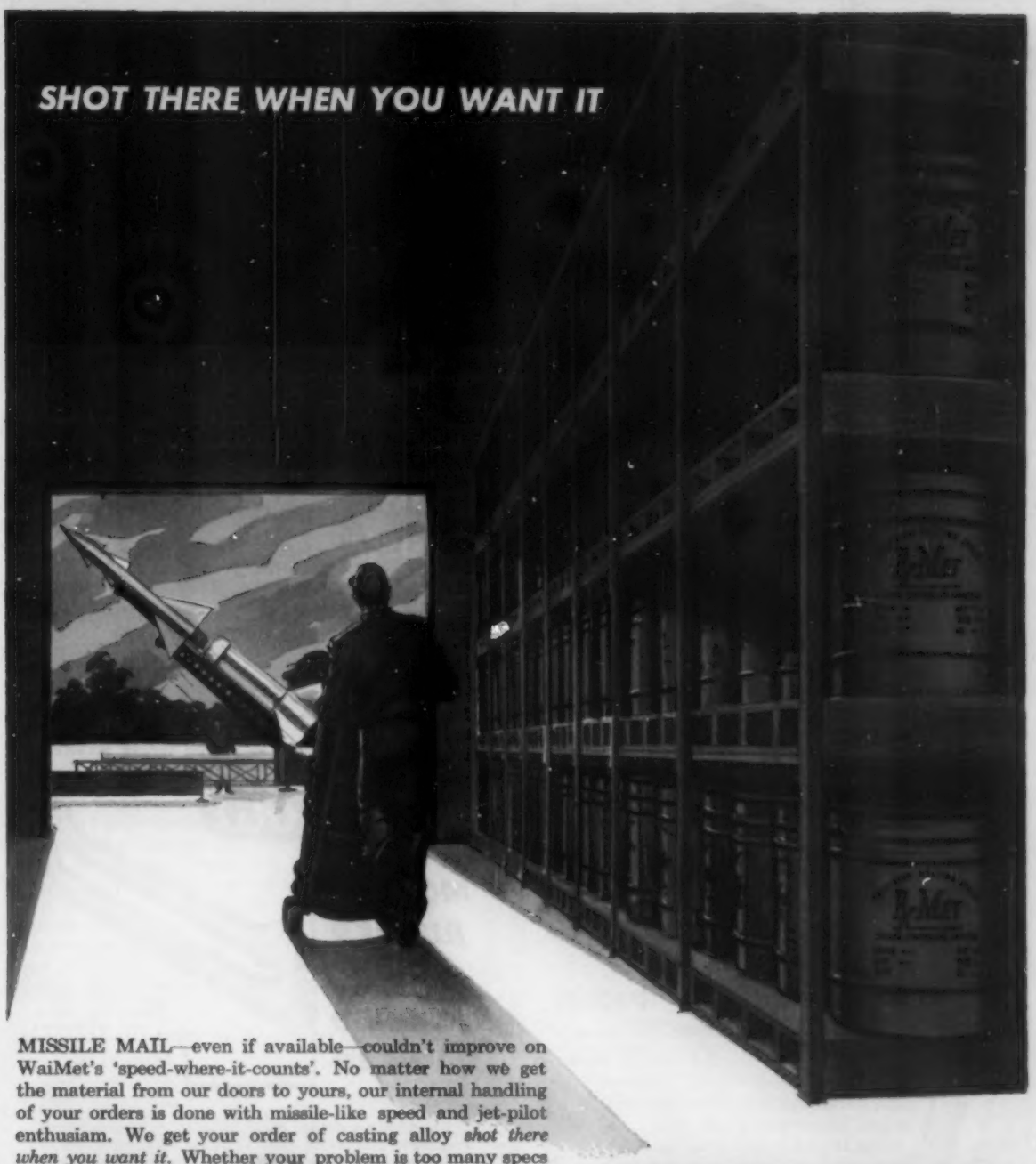

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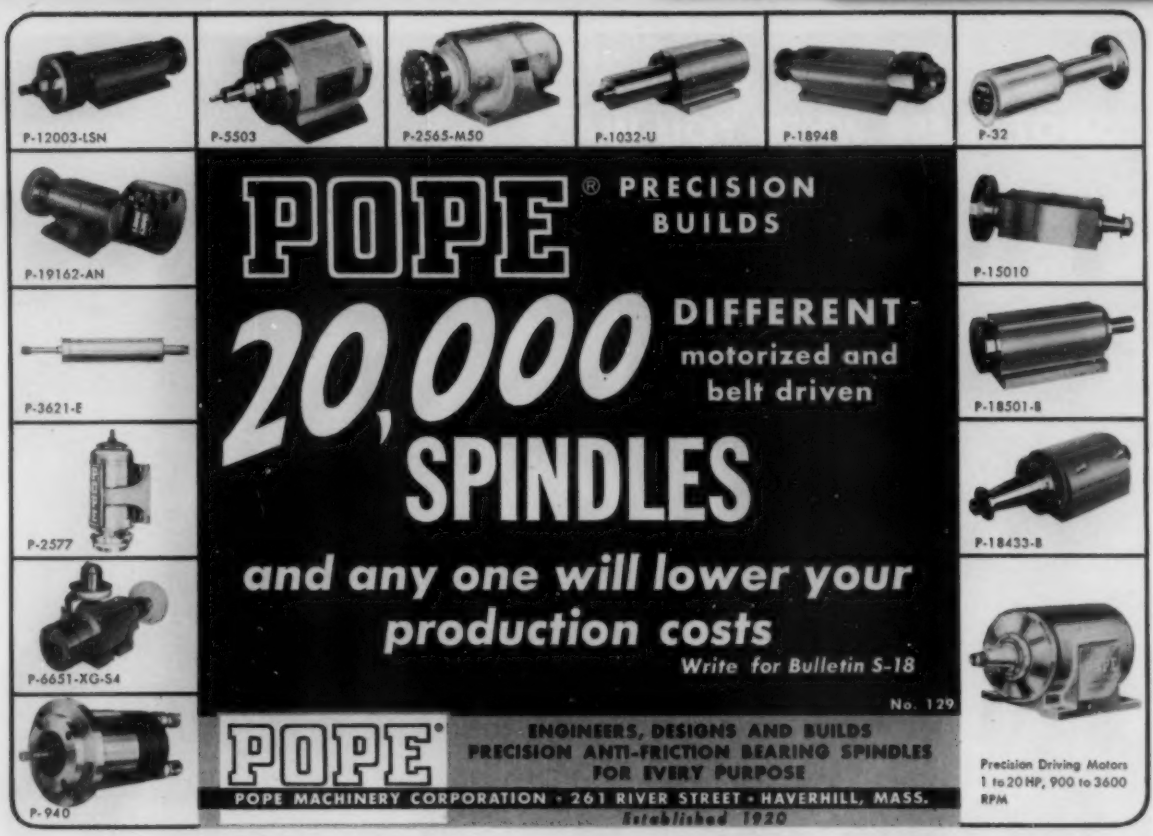

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These ice skate blade guards, molded by WILBOW for Nestor Johnson, are designed to withstand just about the roughest abuse imaginable.

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WILBOW excels at meeting special molded rubber needs with a full line of compounds including the latest synthetic, natural and silicone polymers. Tell us of your mechanical rubber requirements or send for the WILBOW catalog.

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CIRCLE 80 ON READER SERVICE CARD

CIRCLE 205 ON READER SERVICE CARD

per hr with relatively heavy fixture loads. Available with 10- or 18-in.-dia table top and choice of station requirements. **Jackson Fluid Power Co, 16722 E Warren Ave, Detroit 24.**

Circle 323 on Reader Service Card

Midget air cylinders . . .

are double-acting units with 1-in. bores, suitable for air pressures to 125 psig. Six models offer strokes of 1, 2, 3, 6, 9 and 12 in. Body, piston and end plates are brass. Over-all length varies from 4 1/32 to 15 1/32 in., including 1-in. threaded section of piston rod. **A Schrader's Son, Div of Scovill Mfg Co, 470 Vanderbilt Ave, Brooklyn, NY.**

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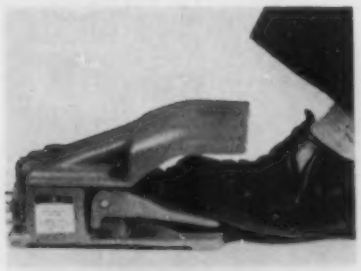

Snap-action foot switch . . .

for control of up to four circuits is constructed of cast iron. Both single- and two-stage forms are available. Each contact unit has one normally open and one normally closed contact. Max current rating is 40-amp make, 15-amp carry. Max voltage is 600 v. Suitable for use in control circuits of contactors or starters through NEMA size 4. Measures 9 1/8 x 5 1/4 x 3 in. without protection guard. **General Electric Co, Schenectady 5.**

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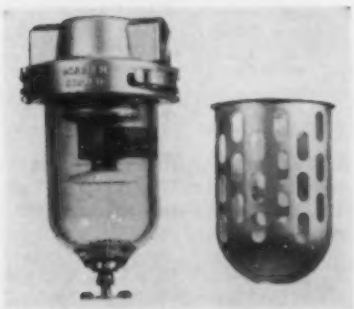


100% removal of liquid . . .

present in compressed air over full range of airflow capacity of air line is said to be possible with new line of air filters. Four optional and interchangeable filter elements are provided for removing solid particles from compressed air. Filter ele-

continued on page 82

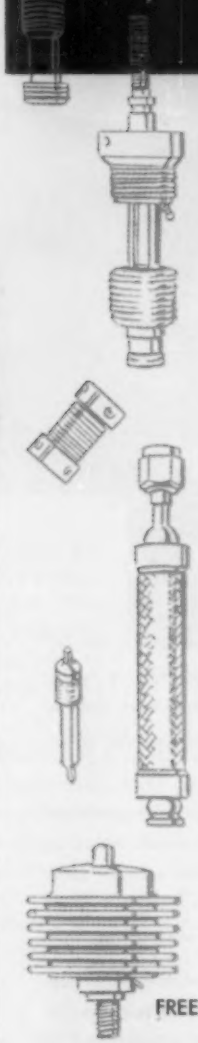
Simple enough: There are too many thousands of applications, each with its own special specs, to carry bellows in stock.

But our engineers have the best know-how in the bellows business. After all, we pioneered with the Sylphon® Bellows back in 1904 and have been in the lead ever since.

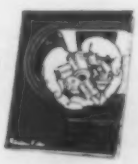
So whatever your design problem —extremely high temperatures or severe pressure stresses—we can supply *custom-formed bellows assemblies* to your most rigid requirements . . . with bellows of stainless steel, phosphor bronze, brass, monel, inconel or inconel-X.

And our *complete* bellows assemblies save you time, trouble, expense . . . and deliver greater long-life efficiency.

Naturally, our bellows-trained engineers are "on call" to work closely with you on design requirements for your particular application.



FREE BELLOWS BOOKLET . . . Ask for GPR-1400



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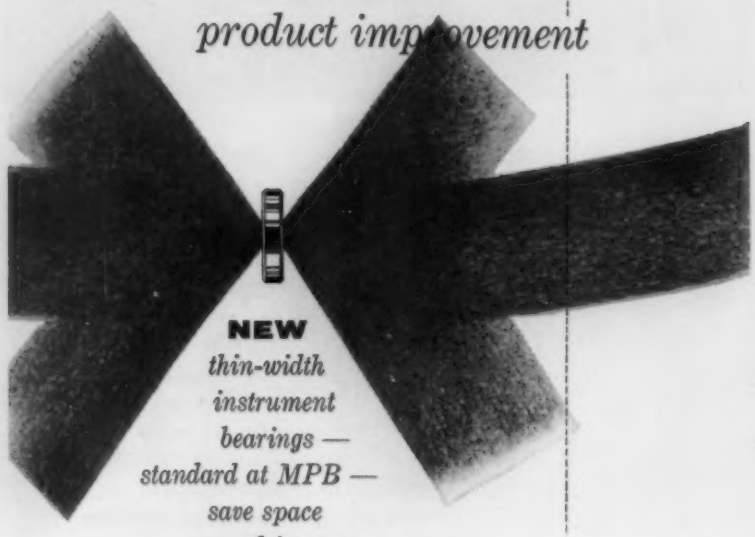


NEW
thin-width instrument bearings — standard at MPB — save space and increase power

Featuring a high ratio of O. D. to width, these new MPB high-precision bearings were originally designed for use in synchros of maximum reliability. Further developed under the MPB policy of working with customers to solve miniaturization problems, the thin-width newcomers have proved ideal for servos, potentiometers, gear trains, motors and other instruments.

In applications like these, a thin-width bearing may also function as a motor end cap, while the motor housing serves as the bearing's outer ring seat. This saving of space results in widely varied product improvement. For example, small power units can use the longer stators or rotors without increasing overall unit length or diameter, thus gaining increased power from the same space.

Your own products may gain exceptional, perhaps unexpected, advantages from the use of MPB thin-width bearings. Made to ultra-precision tolerances of ABEC Class 7, they are available in nine sizes, with O.D.'s from .2750″ to .5000″ and bores .0937″ to .1875″. The new thin-width instrument bearings are not "Specials"; they are a standard series without price premium.

An MPB Sales Engineer will be glad to discuss your application with you. For engineering assistance and/or new bulletin write to Miniature Precision Bearings, Inc., 204 Precision Park, Keene, N. H.

MPB *Helps you perform miracles in miniaturization*

ments can be cleaned and reused. Filter is furnished with 74-micron, 200-mesh, reinforced Monel wire screen. Available with transparent plastic bowl or metal bowl, for higher pressures, temperatures and rougher usage. For use with ¼-, ⅜- and ½-in. pipe sizes. **C A Norgren Co, 3400 S Elati St, Englewood, Colo.**

Circle 326 on Reader Service Card

Expanded Teflon tubing . . .

in thin and standard wall types, recovers original dimensions and shrink fits around inserted object when heat is applied. Retains all Teflon properties. Offered in 11 basic colors, printed and cut to required lengths. Can be made cementable. **Pennsylvania Fluorocarbon Co Inc, 1115 N 38th St, Philadelphia 4.**

Circle 327 on Reader Service Card

Ac, dc motor-load indicators . . .

are offered in a 3½-in. panel meter with 2% accuracy and 4½- and 8¾-in. switchboard instruments with 1% accuracy. Respective scale lengths are 3, 7 and 14 in. Ac models are supplied as either ammeters, which measure percent of motorload current, or wattmeters, which measure percent of horsepower. Dc instrument, an ammeter design, measures dc motor-input current. Ac instruments are available for single- and three-phase, 50- or 60-cps motors. Two standard scales, calibrated from zero to 150%, can be supplied. **General Electric Co, Schenectady 5.**

Circle 328 on Reader Service Card

Redesigned squirrelcage motor

in sizes from fhp to 125 hp includes stator that are encapsulated and impregnated with thermosetting plastic. Die-cast aluminum rotor is supported by double shielded bearings. Three-phase induction motors are sold at NEMA open-motor prices. **Lincoln Electric Co, Cleveland 17.**

Circle 329 on Reader Service Card

Silicon-rectifier stacks . . .

are standard with Style 21 and 33 diodes. Bridge assemblies using Style 21 diodes are rated up to 39 amp, single phase; 58

continued on page 84

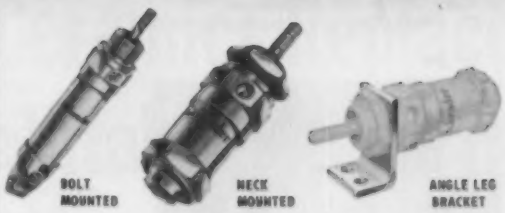
ALL THESE AIR CYLINDERS FROM SCHRADER...

Schrader offers complete lines of double-acting and single-acting air cylinders in 9 bore sizes, with or without cushioned strokes, including JIC cylinders, all in a variety of mountings. They make hard work easy . . . provide powerful push, pull, lift or reciprocating movements . . . and are at work by the thousands in countless plants everywhere.

...AND NOW...POWERFUL NEW MIDGET AIR CYLINDERS

Here they are! Streamlined, compact air cylinders for light duty and gang-type applications . . . rugged . . . only slightly thicker than your thumb! Schrader makes them with strength and precision that will give long trouble-free service even in tough applications requiring extra stamina and speed. Simple to use in any position. Excellent for operating jigs and fixtures, transfer and special purpose machines. Features: No tie rods . . . double-acting . . . popular 1" bore . . . stroke sizes to 12".

Your Schrader distributor is fully stocked with all these air cylinders. He is staffed with factory-trained experts who are fully qualified to help you solve any air control problem and select the right air components to perform jobs best. You'll find him in the yellow pages, or write direct.



Schrader's new midget air cylinders have quality built in . . . cartridge type bronze bearing and piston rod seal . . . non-corrodible solid brass end plates with hexagonal flats and non-corrodible brass cylinder and pistons . . . ground and polished steel piston rod . . . molybdenum disulphide grease packing . . . synthetic rubber "U" cup piston seals.

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QUALITY AIR CONTROL PRODUCTS

CIRCLE 83 ON READER SERVICE CARD 83

amp, three phase. Bridge assemblies using Style 33 diodes are rated up to 75 amp, single phase; 112 amp, three phase. All stacks are available with cell voltages to 600 PIV and in various standard commercial finishes. **Syntron Co, 240 Lexington Ave, Homer City, Penna.**

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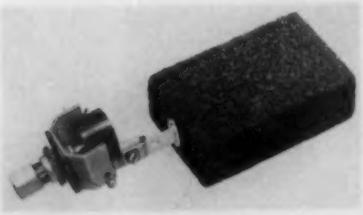

Adjustable valve and float . . . assembly is for use in automatic control applications. Valve operates on single-pivot principle. Adjustable, all-rubber valve seat can be reversed, acts as splash shield. Chrome-plated valve jet provides positive shutoff. Float is foam glass. **Skuttle Mfg Co, Milford, Mich.**

Circle 331 on Reader Service Card

Air and hydraulic cylinders . . . have one-piece square heads, ground and polished stainless steel rods, nylon bearings and honed brass or steel tubes. Available in bore sizes of ⅞, 1⅛, 1½ and 2 in., as either double acting or spring return, as well as double or single ended. Units are stocked in stroke up to 20 in. but any stroke is available up to 168 in. **Allenair Corp, 255 E 2nd St, Mineola, NY.**

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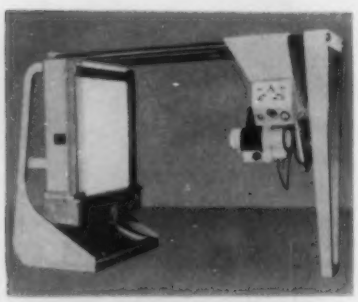

Projector-printer . . . is capable of producing electrostatic prints up to 34 x 48 in. Film is loaded manually into holder, exposure time is set and button is pushed. The rest of the operation is automatic. Prints in only 40 sec. Equipment can make up to 19 prints automatically from a single negative. Unit is 5 ft wide, 14 ft long and 7¼ ft high. Operates on 115 v ac, 50 amp. No venting is required. **Keuffel & Esser, Third and Adams Sts, Hoboken, NJ.**

Circle 333 on Reader Service Card

DESIGN LITERATURE

Electrical Engineering Fundamentals

J P NEAL. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 7 x 10, 402 pp. $8.50.

It is assumed that the reader has had college physics courses in mechanics, electricity, and magnetism; and mathematics courses in analytic geometry, algebra, and calculus. Engineering interpretations of physical characteristics and laws of electromagnetic systems and equivalent mathematical models are in rationalized mks system of measures, using scalars and vectors. A careful review of the essentials of elementary vector mathematics is also included. Covered are: measures of electromagnetic characteristics, vector concepts, local current fields, electrostatic fields, magnetic fields, electromagnetic induction field, electric-network structure, and electric-network analysis.

The Complete Book of Jets and Rockets

D N AHNSTROM The World Publishing Co, 2231 W 110th Street, Cleveland 2. 9½ x 11, 159 pp. $4.95.

This is a picture story of the advances in aviation that have brought us up to the present age of speed, concisely told in simple terms by a recognized historian in the field. The volume is illustrated with over 100 photos and diagrams that compliment the text. Many interesting and unusual anecdotes which were previously unpublished are included. Though not intended as a technical source, the book is comprehensive enough to be used as a starting point for further study.

A Study of the Purdue University Graduate

Published by Purdue University and available from Engineering Experiment Station, Purdue Univ, Lafayette, Ind. 8½ x 11, 300 pp. $2.50.

From questionnaires answered by 3,799 of its engineering alumni, Purdue University has collected a massive amount of data pertaining to opinions of engineers as a group. The questionnaire, distributed in 1957, asked questions in five areas: College experience, opinions about an engineering curriculum, job experiences, personal information, opinions about education and Purdue University. The value of the material is reduced by the overdetailed, poorly organized method of presentation. The appendix contains a copy of the questionnaire and the statistical computation used in preparing the results.

Space, Time and Gravitation

SIR ARTHUR EDDINGTON. Harper & Brothers, 40 E 33rd St, New York 16. 5¼ x 8, 216 pp. $1.35.

Subtitled "An Outline of the General Relativity Theory," this is a paper-backed edition of the original work by the famous English astronomist. Essentially a nonmathematical presentation of the basic notions of both the special and the general theory of relativity, the discoveries of Einstein, Minkowski, Hilbert, Lorentz, Weyl, Robb and others are discussed in a manner certain to be of interest to the engineer with a taste for the sciences on which his work is based. Eddington wrote with a clarity and freshness of perception that cannot fail to delight all followers of the rigorous arts.

Econometrics

STEFAN VALAVANIS, assistant professor of economics, Harvard University. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9¼, 223 pp. $7.

A short introduction to econometrics, this book (edited from a manuscript by Alfred H. Conrad, Assistant Professor of Economics, Harvard University), relates the techniques by which economic theories are brought into contact with the facts. It is intended for a first course in econometrics and proceeds much more by statements of problems and examples than by the development of mathematical proofs.

Within the field of econometrics, the book is especially addressed to the problems of estimation, and its orientation is always toward the strategy of research. The emphasis is on estimating, from the insufficient material available, the values or magnitudes of the variables and relationships suggested by economic analysis. The maximum-likelihood techniques are developed from fundamental assump-

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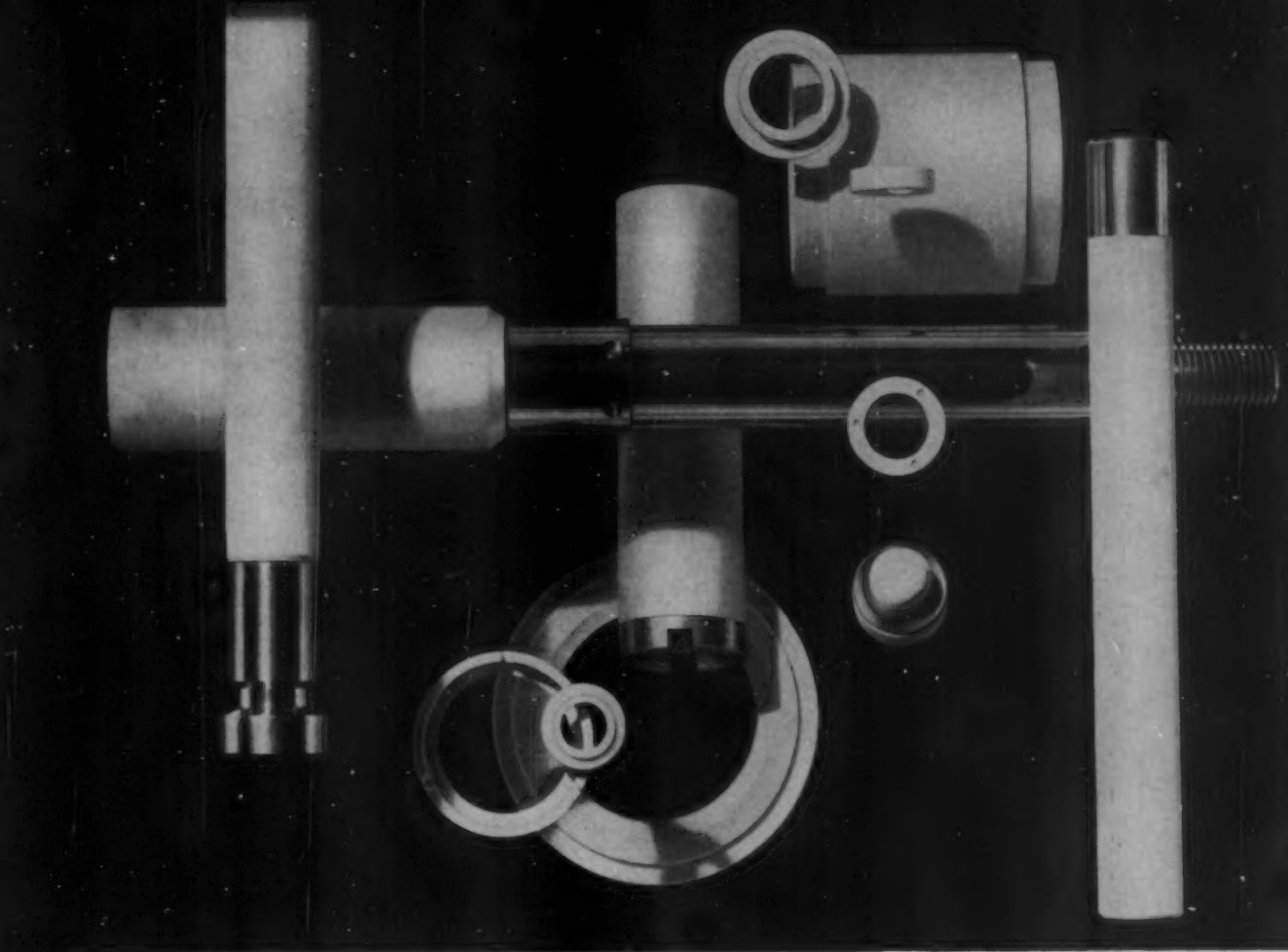

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In addition to Coors Ceramics ability to withstand corrosion and abrasion, they also have excellent strength characteristics — plus dimensional stability. They do not warp or change shape. That's one reason they are used for seal faces in shaft seals ... when you lap these materials flat, they stay flat!

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BRUSH SHOWS THE WAY TO

FUSION WELD BERYLLIUM

THE SPACE AGE METAL

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Now Brush engineers can show you the way to fusion weld the metal. Nonporous and crack-free beryllium weldments, with properties superior to the base metal at elevated temperatures, have been achieved. At this stage, virtually all of this welding has been done on a laboratory basis. When present development work is completed, we feel we'll be ready to try our wings, or help you try yours, on fusion welding this space age metal under production conditions.

The development of fusion welding, mechanical fastening, brazing, soldering, and other joining methods greatly broaden application horizons for beryllium.

Can this metal, its oxide, its alloys or our expanding experience with these versatile materials solve a problem for you? Let us try. Contact us at 5209 Euclid Avenue or ENdicott 1-5400 in Cleveland, Ohio.

X-ray of a one-quarter inch thick beryllium weldment.

THE BRUSH BERYLLIUM COMPANY

Dispenses all lubricating oils up to 25,000 SSUV at 100° F.

Revolutionary

new

ALEMITE OIL-MIST SYSTEM WITH thermo-aire

Now! Automatic Lubrication for:

Heavy-duty bull gears!

Heavily loaded plain bearings!

Heavy-duty chains!

Heavy-duty slides and ways!

Largest size anti-friction bearings!

Now even your heavy-duty bearing surfaces can be lubricated continuously and automatically with the required high viscosity oils! An exclusive new "Thermo-Aire" feature on Alemite's Oil-Mist System preheats incoming air. This preheated air permits the atomization of the heaviest straight mineral oils.

The "Thermo-Aire" unit brings all the advantages of Alemite Oil-Mist to heavy-duty lubrication. You get automatic, continuous lubrication . . . eliminate guesswork, cut oil consumption (up to 90%). You prevent product damage caused by oil drippings, extend bearing life, eliminate waste, save manhours, get greater safety, eliminate machine downtime and reduce the number of lubricants needed.

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Symbol of SW Excellence

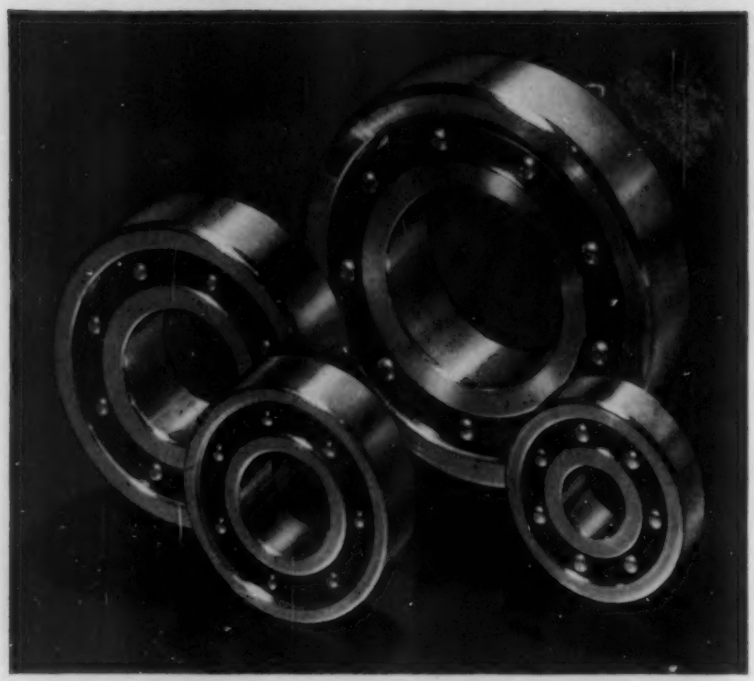
ALEMITE
DIVISION
STEWART-WARNER
CORPORATION

1850 DIVERSEY PARKWAY, CHICAGO 14, ILLINOIS

CIRCLE 87 ON READER SERVICE CARD

900° F. STOCK BEARINGS

PERMIT RAPID SOLUTIONS TO HIGH-TEMP PROBLEMS



TYPE: Deep groove radial.	RETAINERS: Machined, land riding.
SIZES: 200, 202, 204 and 206.	ACCURACY: ABEC-5.
BALLS AND RACES: High speed steel.	LUBRICATION: None.

THESE NEW ITI ball bearings are for use at elevated temperatures up to 900° F. At such temperatures, their load capacity is greater than any other bearings of like size, and they have unusual dimensional stability. They open new horizons in developmental work, because (1) they provide a first approximation to the solution of a wide range of high-temperature bearing problems; (2) they're *available from stock;* and (3) they *cost far less* than custom-made experimental bearings.

The suitability of a bearing to *any* high-temperature application depends on many factors.* Upon receipt of application data, we will tell you whether these "off-the-shelf" bearings will serve your purpose. Prices and other details are also available; and we invite your inquiry.

*FREE BULLETIN AFB-2 gives details; also describes our work in *custom-engineered* bearings. Write for it.

INDUSTRIAL TECTONICS, Inc.

ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3670 JACKSON RD., ANN ARBOR, MICH.

BEARING DIVISION PLANT: COMPTON, CALIFORNIA

tions and criteria and demonstrated by example; their costs in accuracy and computation are weighed. Identification and hypothesis-testing are carefully treated.

Pedagogical and exacting though the book is, it is also lucid and informal. Statistical tools are always presented in terms of the fundamental limitations and criteria of the real world. Almost every concept is introduced by examples in the setting of the real problems being discussed.

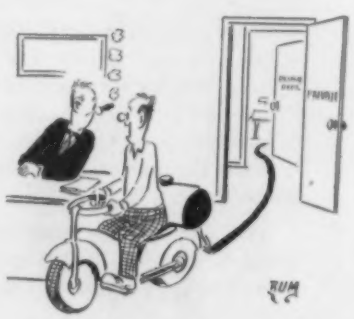
Frank Lloyd Wright Drawings

Horizon Press Inc, 230 W 42nd St, New York 36. 14 x 11¾, 255 pp. $35.

For the engineer or other technically minded person interested in arriving at his own independent appraisal of the work of this most controversial of all architects, perhaps this collection of his drawings of his own buildings will prove the most rewarding. Certainly it is likely to remain one of the most expensive, at this price!

But it is a beautiful volume, and in those full-color sketches and renderings of buildings—some now existing, some demolished and some never built—which include their natural settings, the exactness of Wright's grasp of the technical and mathematical basis of his work is self-evident. The drawing exercise done by Wright for his course in civil engineering in 1885 (it shows the form and shadow of a form generated by a parabola about its axis) reproduced on the copyright page, the drawings for ornamentation, the cross-sectional working drawings of construction detail must impress every engineer, regardless of his evaluation of Wright's contributions to the shape

continued on page 90



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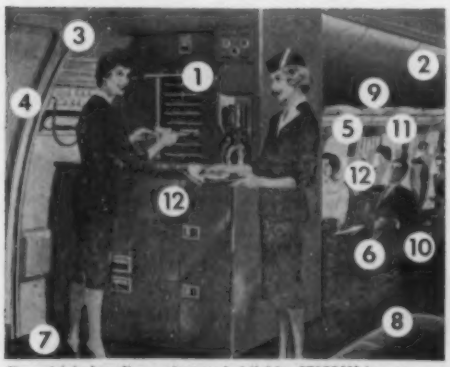
...made possible with flexible and rigid **stafoam**



Newest jet aircraft use stronger-but-lighter STAFOAM in many forms to provide passenger comfort and protection.

To create home-like comfort at 30,000 feet manufacturers of today's jet passenger liners faced countless new challenges – and solved them in an amazing number of cases with versatile STAFOAM urethane. Whether used for insulating, bonding, padding, or sealing, for transparent windows or foamy chair cushions, the plus-properties of STAFOAM provide the superior service essential to Space Age materials. You, too, will find a new dimension of material technology in miraculous STAFOAM. Take your next product problem to the Freedlander R & D Laboratories, American Latex Products Corp., or its branches.

Stafoam applications:

1. INSULATION OF GALLEY FOOD CHAMBERS 2. WALL PANELING THROUGHOUT SHIP 3. POLYRUBBER DOOR GASKETS 4. FOAM CORE IN DOORS 5. WINDOW GASKETS 6. SEAT CUSHIONING (HARDMAN DIVISION) 7. FLOOR MATS 8. CARPET UNDERLAY 9. LUGGAGE RACK SHOCK PADDING 10. FOOT RESTS 11. POLYPOT WINDOW "GLASS" 12. STABOND ADHESIVES FASTEN METAL GALLEY AND SEAT COMPONENTS

AMERICAN LATEX BRANCHES: SAN FRANCISCO, 42 Gough St.; SEATTLE, 2231 5th Ave.; DALLAS, 1300 Crampton St.; HOUSTON, 401 Velasco; OMAHA, 3304 N. 48th Ave.

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D R HEADQUARTERS FOR NEW IDEAS

STAFOAM RIGID	STAFOAM FLEXIBLE	POLYRUBBER	POLYPOT	DAYCOLLAN
Thermal insulation	Aircraft & conveyance seating	Personnel shock padding	Instrument potting	Gear, roller bearings, O rings
Acoustic dampening	Commercial cushioning	Instrument & motor mounts	Crystal clear windows & mtrls.	Instrument & control knobs
Foam core construction	Shock padding (high hysterisis)	Elastomer coupling	Control knobs & accessories	Instrument scope boots
Helmets and liners	Clothing insulation & liners	Oxygen hose and masks	Electronic encasing	Airless wheels & tires
Packaging & flotation	Air & liquid filtering	Window and hatch gasketing	Applicable hardware	Applicable hardware

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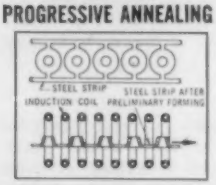
Lepel induction heating equipment represents the most advanced thought in the field of electronics... the most practical and efficient source of heat developed for numerous industrial applications. You are invited to send samples of work with specifications. Our engineers will process and return the completed job with full data and recommendations without cost or obligations.

TYPICAL INDUCTION HEATING APPLICATIONS

PLASTIC COATING OF TOOL HANDLES

A production line operation for coating handles of tools at Whitney Metal Tool Co., Rockford, Ill. uses induction heating with excellent results. The handles only are heated by induction to the desired temperature then dipped into a vinyl chloride base coating material for a short period depending upon the thickness of coating desired. The plastic coating formed on the handles is then cured by immersion in a carbo-wax bath.

FORMING OF METAL STRIP FACILITATED BY PROGRESSIVE ANNEALING



Metal forming operations which require intermediate anneals to restore ductility can be facilitated by induction annealing the strip progressively. Diagram illustrates this procedure for partially formed thin austenitic stainless steel strip. The induction annealing operation is scheduled in the production line between two press operations. Metal strip and wire of other materials are also induction annealed in this manner.

WRITE FOR NEW LEPEL CATALOG
Electronic Tube Generators from 1 Kw to 100 Kw.
Spark Gap Converters from 2 Kw to 30 Kw.

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of our buildings and other products.

A new appreciation of Wright's work is also included in this book, prepared especially by Professor Giuseppe Samona of the University of Venice. JK

Ultrahigh-strength Temper-resistant Steels

H B NUDELMAN, J P SHEEHAN, Armour Research Foundation. 151971 (WADC Technical Report 59-86). Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 25 pp. $1.

In this test program, molybdenum, chromium, vanadium and tungsten were evaluated for their ability to impart temper resistance to the ultrahigh-strength steels. Some of the modified steels maintained their hardness—from RC 40 to 59—after exposure to 1 hour at 1300 F. Unfortunately, longer time data was not taken and the temper resistance was judged strictly by hardness. This is not a true indication of tensile or fatigue strength, as may be inferred from the booklet's title, "Development of Ultrahigh-strength, Temper-resistant Steels Designed for Improvement of Fatigue Properties Through Relief of Residual Stress."

Telemetering Systems

P A BORDEN, W J MAYO-WELLS. Reinhold Publishing Corp, 430 Park Ave, New York 22. 9½ x 7, 349 pp. $8.50.

Practical aspects of stationary and mobile telemetering devices—with commercial examples—are given in easy-to-read chapters. Telemetering systems covered are current, voltage, frequency, position, and impulse. Topics also covered are pickups, links and channels, coordinating, totalizing, computing, and integrating, remote reading of meters and registers, selection and application of telemetering systems, and reliability and testing.

Other Books of Interest

Thermistors and Varistors

Victory Engineering Corp, 546 Springfield Rd, Union, NJ. 5½ x 8½, 39 pp. $1.

Structure and Properties of Thin Films

Edited by Neugebauer, Newkirk, Vermilyea. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 8½ x 11, 561 pp. $15.

The first English-language report on the structure and properties of thin films, this book presents the complete proceedings of an international conference on thin films held at Bolton Landing, Lake George, NY.

Modern Network Analysis

Reza and Seely. McGraw-Hill Publishing Co Inc, 330 W 42nd St, New York 36. 6 x 9, 373 pp. $10.

The Economic Almanac, 1960

Edited by J Gaston. Newsweek, 444 Madison Ave, New York 22. 5 x 7½, 673 pp. $7.95.

A handbook of useful facts about business, labor and government in the United States and other areas.

Materials and Techniques for Electron Tubes

Walter H Kohl. Reinhold Publishing Corp, 430 Park Ave, New York 22. 6 x 9, 638 pp. $16.50.

Provides composition, properties and behavior of the materials used in electron tubes and the techniques for assembling these materials.

Defense R & D Contracts Guide

Edited by J L Lewis. Order from Vincent F Callaham, Evans Bldg, Washington 5, DC. 8½ x 11, 212 pp. $25.

How and where to sell your R & D capabilities to the Armed Forces.

Spray Formation and Breakup, and Spray Combustion

PB 151645. A E Fuhs. Office of Technical Services, Dept of Commerce, Washington 25, DC. 7¾ x 10¼, 132 pp. $2.75.

Practical Design Guide

R A Rinehuls. Pelex Publishers Inc, 95 Liberty St, New York 6. 8¾ x 11½, 132 pp. $3.50.

Discusses hydraulics and pneumatics, mechanical systems and components, electrical circuits.

A Treatise on Algebraic Plane Curves

J L Coolidge. Dover Publications Inc, 180 Varick St, New York 14. 5¼ x 8, 513 pp. $2.45.

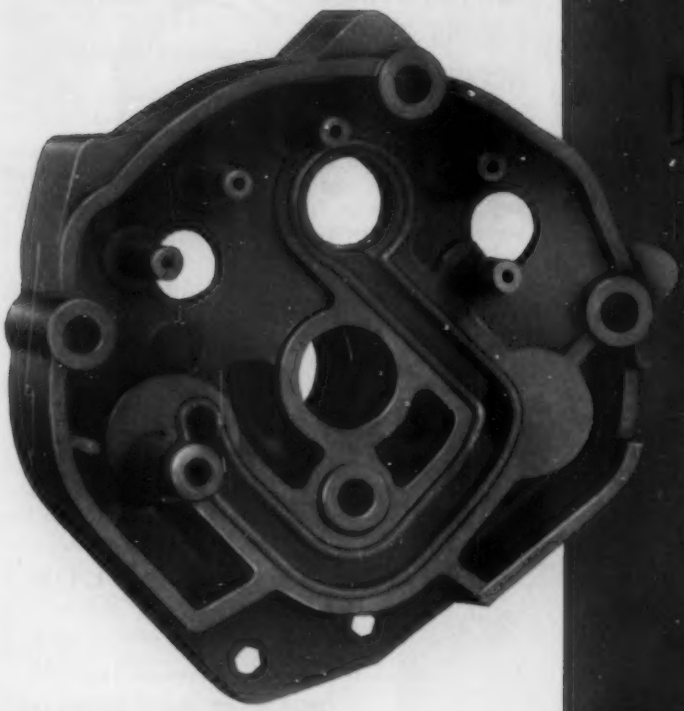
Thermoelectricity Abstracts

PB 151657. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 104 pp. $2.50.

Both early and current sources are included, from foreign as well as domestic publications.

continued on page 93

"The trouble with you, Curtis, is that you have no imagination."



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In the DOLE VALVE COMPANY'S AUTOMOTIVE VACUUM SERVO CONTROL HEAD the intricate shape, the tubes, the gasket grooves and holes are all cast to size.

This is a prime example of maximum utilization of the die casting process.

The skilled and cost-conscious mechanics at Madison-Kipp worked closely with the valve designer to create a component of excellence and low secondary labor content.

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- Experienced in Lubrication Engineering
- Originators of Really High Speed Air Tools

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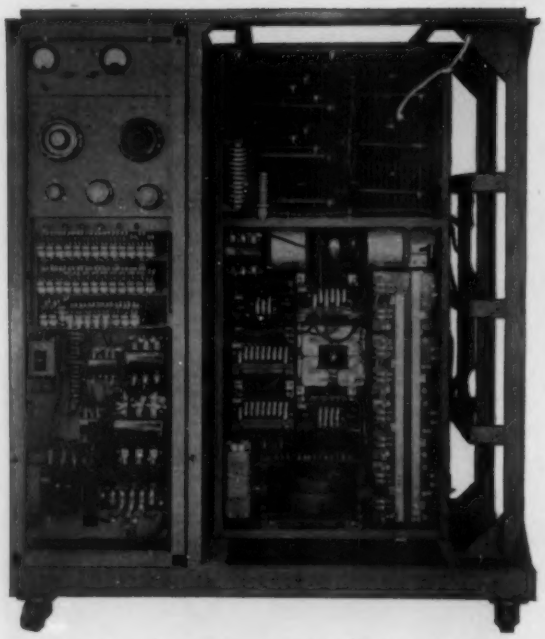
CIRCLE 91 ON READER SERVICE CARD



Regulated, multiple voltage output +250 volts, +150 volts, +70 volts, +70 volts, +250 volts, −35 volts, −50 volts, −60 volts, −70 volts, −250 volts D.C. 6.3 volts, 115 volts, A.C. Total power capacity approx. 15 KW

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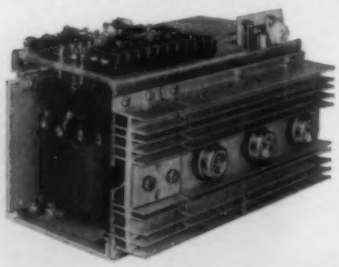
"*Know* your supplier" is pertinent advice as it applies to the design, engineering and construction of power supplies. Acme Electric not only knows the state of the art but is a recommended supply source. That's why you can expect specific advantages based on engineering experience, and backed-up by manufacturing facilities and trained manpower. If power supplies are an important part of your products, it will pay you to investigate the part Acme Electric can play in your procurement program.



Series regulated
Output 120, ±1% dc
● 0-6 amps.

ACME ELECTRIC CORPORATION

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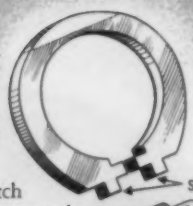
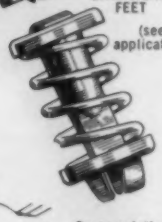
BAA 2420/1872

Acme ACME Electric
TRANSFORMERS

SPRING LOADED LATCH for removable panels and access doors

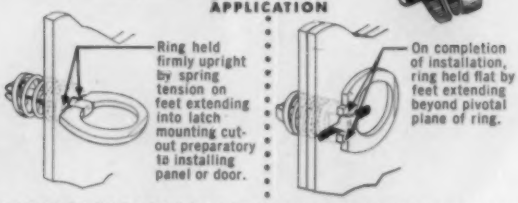




Completely assembled, installed in 5 seconds. Latch slips through hole, ring is snapped on. ¼ turn to operate. Spring tension eliminates noise transmission and vibration. Simple hole preparation. Eliminates riveting, screws, spot welding. Inexpensive.

Write for circular.

APPLICATION


Ring held firmly upright by spring tension on feet extending into latch mounting cut-out preparatory to installing panel or door.
On completion of installation, ring held flat by feet extending beyond pivotal plane of ring.

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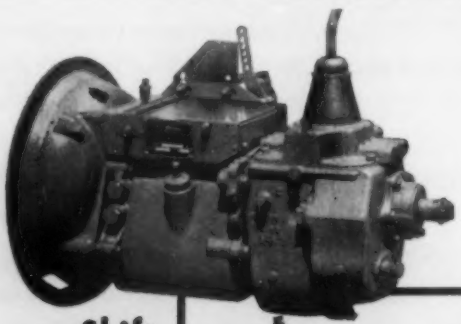
MONADNOCK MILLS
SAN LEANDRO, CALIFORNIA
SUBSIDIARY OF
UNITED-CARR FASTENER CORP., BOSTON, MASS.
OFFICES: ATLANTA, BOSTON, CHICAGO, CLEVELAND, DALLAS, DETROIT, LOS ANGELES, NEW YORK, PHILADELPHIA, SYRACUSE

CIRCLE 206 ON READER SERVICE CARD



Shift Problem Solved *with* FUNK revers-O-matic®

On this Browning Road Roller, a FUNK Revers-O-Matic® allows the operator to change both speed and direction — *with just one lever*. Hands are left free for other operations. Shifting is smooth and instant, with no wheel spinning.

Another example of how standard FUNK MODULAR POWER UNITS may be combined to handle a *special* job, *without* special engineering costs. Let FUNK help with your power problems.

FUNK MFG. CO. Box 877-D, Coffeyville, Kansas

Algebraic Theories
L E Dickson. Dover Publications Inc, 180 Varick St, New York 14. 5¼ x 8, 276 pp. $1.50.

An Elementary Treatise on Fourier's Series
W E Byerly. Dover Publications, 180 Varick St, New York 14. 5¼ x 8, 287 pp. $1.75.

Information Please Almanac, 1960
McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 5 x 8, 912 pp. $1.25.

ABSTRACTS FROM THE LITERATURE

Design of Forgings

Presents the basic principles of forging and shows how the designer can apply them most satisfactorily. A table of drop-forging thickness, surface and offset tolerances is included along with 8 illustrated examples of principles.

"Design Principles of Forging," R. C. Jones, Head Wrightson Stampings Ltd. Engineering Materials and Design, March '60, Drury House, Russell St, London, WC 2, England.

Nomographs Aid Design

For a complex cam-and-tappet contact-stress equation, seven nomographs supply the desired solution. It was found that answers were accurate to within 0.5% when compared with computer-calculated answers.

"The Application of Nomograms to the Solution of an Engineering Problem," General Motors Engineering Journal, Jan-Feb-Mar '60, Box 177, North End Station, Detroit.

Ballbearings in Controlled Atmospheres

Results are given for tests of ballbearings run in hydrogen, helium and nitrogen-hydrogen atmospheres free of oxygen and water vapor. Satisfactory performance was noted provided there was adequate lubrication with petroleum or turbine oils. Polishing action of pure gases was noted particularly.

"The Behavior of Lubricated Ballbearings in Controlled Atmospheres," W. A. Glaeser, Battelle Memorial Institute. Lubrication Engineering, Feb '60, 5 N Wabash Ave, Chicago 2.

Evaluating Results of Accelerated Tests

Mathematical criteria are developed that indicate the conditions under which reliability data obtained from

continued on page 95

BRAD FOOTE gears ...FOR A WORLD AT WORK

BRAD FOOTE's DEEP CASE HARDENING process has been perfected to a degree which practically eliminates distortion

GEARS RUN TRUE
No place is distortion control more important than on heavy duty gears which are run almost continuously at full rating and subjected to extreme shock loads such as are encountered in rolling mill operations. BRAD FOOTE **DEEP CASE HARDENED** gears run true and distribute the load evenly across the full face and on the designed bearing surfaces of each tooth.

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In addition, BRAD FOOTE rigidly controls to set standards the depth of **DEEP CASE HARDENING** and the carbon content. The tooth surfaces are wear-resistant and of maximum hardness for long life, but the carbon content is gradually diminished at successive depths below the surface until it blends to the metal of the core itself.

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Thus the cores of the teeth and the body of the gear remain ductile and shock-resistant while the teeth are given an increase in service life of over 50%.

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Your order for BRAD FOOTE Gears will be processed by an experienced organization of gear specialists and produced on the most extensive and versatile facilities available. Maximum performance and your complete satisfaction are assured.

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Spiral Bevel	Internal Gears
Herringbone	Reducers
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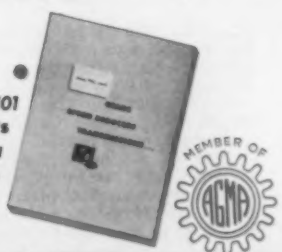
Find out what BRAD FOOTE's two generations of gear building experience can do for YOU.
Write today



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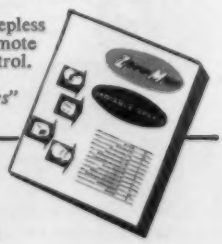

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CIRCLE 94 ON READER SERVICE CARD

CIRCLE 209 ON READER SERVICE CARD

accelerated tests can be used to predict reliability in normal use. In addition, a simple model-prototype relation is developed that is suitable for application to accelerated test programs when environmental stresses are negligible.

"Accelerated Testing as a Problem of Modeling," Gary and Thomas, Battelle Memorial Institute. Presented at Sixth National Symposium on Reliability and Quality Control in Electronics, Jan 11-13, 1960. Battelle Memorial Institute, Columbus 1, Ohio.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 97.

GRADED INSTRUMENT GEARS – Catalog, 96 pp. Instrument gears, pinions and racks are graded for quality, material and price. Contains selection in pitch range of 20 to 120. Section 2 covers design information, characteristics and performance data. Armac Gears, Div Franke Gear Works, 4401 N Ravenswood Ave, Chicago 40.

Circle 350 on Reader Service Card

MOLYBDENUM MILL PRODUCTS–Specifications brochure, 22 pp. Compilation of unalloyed molybdenum and Mo-0.5 Ti alloy billets, bars, plates and sheets. Material specifications for each include manufacture, chemical composition, structure, mechanical properties, dimensions, finish and inspection. Refractomet Div, Universal-Cyclops Steel Corp, Bridgeville, Penna.

Circle 351 on Reader Service Card

RELAYS–Manual, 46 pp. Features 30 types of relays. Includes photos, line drawings, tables, descriptive material, ratings and specifications. Diaphlex Div, Cook Electric Co, 2700 Southport Ave, Chicago 14.

Circle 352 on Reader Service Card

POWER SUPPLIES–Handbook and catalog, 32 pp. Specifications on more than 400 separate power supply models are given in tabular form. Information also on selection and application of these products. Sorenson & Co, South Norwalk, Conn.

Circle 353 on Reader Service Card

HYDRAULIC EQUIPMENT – Catalog, about 60 pp. Descriptions and specifications of pumps, valves, cylinders, motors, hand pumps and power units. Dynex Inc, 777 Dynex Dr, Pewaukee, Wis.

Circle 354 on Reader Service Card

ALUMINUM ALLOYS–Booklet, 24 pp. Describes physical properties, fabrication characteristics and product specifications. Discusses tempers, finishes and patterns. Olin Mathieson Chemical Corp, 400 Park Ave, New York 22.

Circle 355 on Reader Service Card

THERMOCOUPLES–Catalog, 26 pp. Specifications and descriptions of various temperature-sensing elements. Section contains information on design, identification and application of thermocouples. Temptron Inc, 7030 Darby Ave, Reseda, Calif.

Circle 356 on Reader Service Card

AIR-OPERATED VALVES – Bulletin HB-7, 8 pp. Construction details, operating characteristics and specifications of HB series. Included is section on valve sizing and flow coefficients. Shows line of close-coupled valve actuators. Conoflow Corp, 2100 Arch St, Philadelphia 3.

Circle 357 on Reader Service Card

CAST HIGH-ALLOY DESIGNATIONS –List, 4 pp. Gives revised list of standard designations and chemical-composition ranges for heat- and corrosion-resistant cast alloys. Alloy Casting Institute, 1001 Franklin Ave, Garden City, NY.

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VACUUM-MELTED, HI-TEMP ALLOY –Technical data 52-263, 12 pp. Covers metallurgical characteristics, physical and mechanical properties, availability and material processing of alloy. Photomicrographs show structures of material. Tables and graphs illustrate properties. Westinghouse Electric Corp, Metals Plant, Blairsville, Penna.

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METAL-FABRICATING FACILITIES–Brochure, 12 pp. Describes facilities for manufacture and processing of magnesium and aluminum. Ten tables cover composition, characteristics, physical and mechanical properties, fabrication limits and dimensions of magnesium. Dow Metal Products Co, Midland, Mich.

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ENGINE AIR FILTERS–Catalog, 1960, 48 pp. Lists size and performance characteristics of more than 110 different dry-type air filters. Includes airflow requirements and airflow curves of filters. Typical installations are illustrated. Fram Corp, Providence 16, RI.

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SELF-LOCKING INSERTS AND TAPPED HOLES–Catalog, 8 pp. Specifications and application information on self-locking inserts and tapped holes. Cross-section drawings illustrate features. Boots Corp, Newtown Turnpike, Norwalk, Conn.

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STEPLESS ELECTRICAL CONTROL–Bulletin 5.501, 4 pp; specification sheet, 4 pp; price list. Bulletin illustrates how unit can change $\frac{1}{10}$-in. mechanical motion into stepless control of up to $\frac{1}{4}$-kw power. Spec sheet contains selection information. Electric Regulator Corp, Pearl St, Norwalk, Conn.

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MULTIPLE-SURFACE STAINLESS FILTERS–Bulletin M-208A, 8 pp. Information on porous stainless steel filters, new filter types and sizes, fabrication, particle-size removal, flow rates and operation. Micro Metallic Div, Pall Corp, 30 Sea Cliff Ave, Glen Cove, NY.

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LOW-PRESSURE-DROP CONTROLS–Folder 2305-7, 4 pp. Covers ratings, specifications and performance of automatic flow controls that offer low pressure drop. Automatic Controls Div, Hays Mfg Co, 803 W 12th St, Erie, Penna.

Circle 365 on Reader Service Card

CERAMICS–Folder 42-874, 4 pp. Contains table of mechanical and electrical properties of high alumina and steatite ceramics and lists design considerations. Also contains two conversion tables–for temperatures and decimal equivalents. Centralab, Electronics Div of Globe-Union Inc, 900 E Keefe Ave, Milwaukee 1.

Circle 366 on Reader Service Card

T-RETAINER BEARING–Data sheet T-1, 4 pp. Features, applications, performance characteristics and ratings are covered. With dimensional information and drawings. Barden Corp, 200 Park Ave, Danbury, Conn.

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CUSTOM ELASTOMERS–Bulletin 902, 6 pp. Discusses design capabilities of custom compounds. Two-page chart lists general properties of 10 major elastomers. Describes origin and composition, lists

continued on page 97

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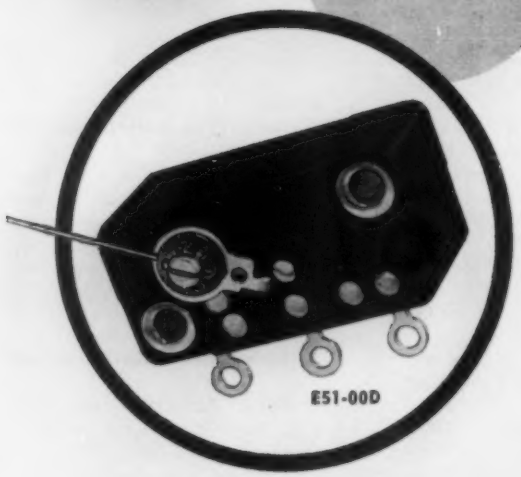

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physical and chemical properties, processing properties and environmental resistance characteristics. Lord Mfg Co, Erie, Penna.
Circle 368 on Reader Service Card

HYDRAULIC ACCUMULATORS–Bulletin 1530B1, 4 pp. Explains why and how accumulators are used. Describes piston-type accumulators ranging in capacity from 10 cu in. to 10 gal. Parker Hydraulics Div, Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.
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LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

PRECISION INSTRUMENT COMPONENTS STANDARDS–Loose-leaf manual, over 400 pp. Components and specifications are produced on reproducible tracing paper, 8½ x 11 in. Offered only to department heads. Pic Design Corp, Sub of Benrus Watch Co Inc, 477 Atlantic Ave, E Rockaway, NY.

FUSION WELDING ALUMINUM–Booklet, 32 pp. Covers these types of welding: gas, metal-arc; tungsten-inert-gas; straight-polarity, tungsten-inert-gas; metal-inert-gas. Also TIG welded-joint design and MIG welded-joint design. Reynolds Metals Co, Dept PRD-31, Richmond 18, Va.

STRUCTURAL ADHESIVES–Catalog, 16 pp. Discusses types and properties of adhesives, proper design methods for structural adhesive bonding, typical joint designs and fabrication methods. Case histories illustrate how adhesives are used to solve structural-assembly problems. Minnesota Mining and Mfg Co, 900 Bush Ave, St Paul 6.

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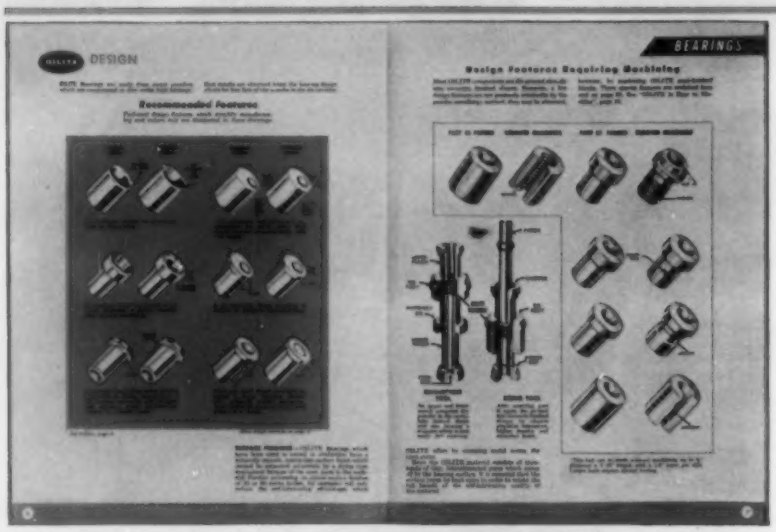

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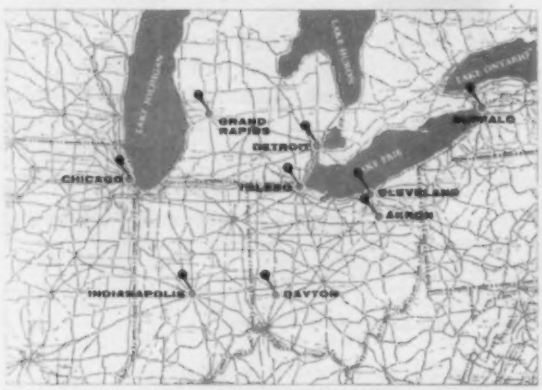

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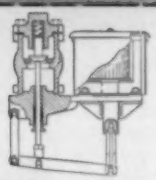

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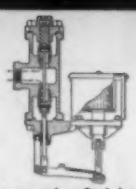

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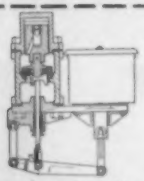

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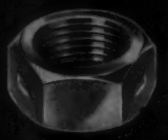

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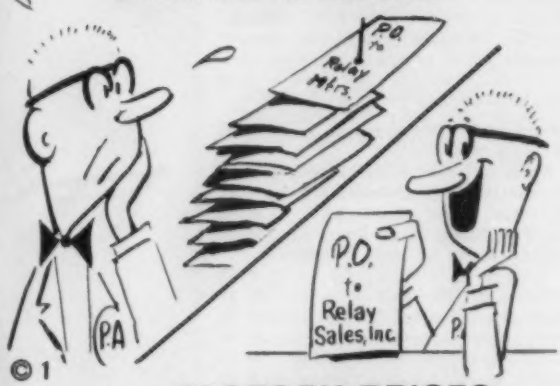

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See Sweet's 1960 Prod. Des. File, 7/E

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THE TECHNICAL STORY: Backward, but not retarded

E. F. BOOMHOWER* and R. W. SLADE*

When the busy scientist, engineer, or executive picks up a novel, a magazine, or a book of poetry, he is prepared to spend considerable time—for *entertainment*. But when he picks up a memo, letter, or technical report, he begrudges every wasted minute looking for the *information* he wants. In fact, important information is often lost to those who need it most, because they can't afford the time to dig it out of a badly organized document.

How, then, would you respond to a report that began like this:

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or perhaps something like this:

"At 9:00 a.m. on October 16, 1959, E. Q. Bungle, Manager of Project Squeeze called a meeting in his office. The purpose of this conference was to discuss the feasibility of a systems proposal by J. P. Snavely, renowned engineer whose cryogenic multivibrator

* *Messrs. Boomhower and Slade, both graduate engineers, are technical editors with the IBM Data Systems Division, Poughkeepsie, N. Y.*

continued on page 103

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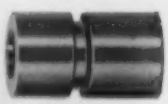

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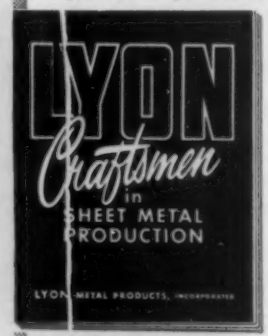

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mounted entirely within a plated-thru hole was the keystone of Project FREEZE. At exactly 9:14, Dr. Bungle's secretary was sent out for coffee, after which the financial survey of the system was presented. This involved . . ." and so on . . . until somewhere at the bottom of page 10 or 12 the author finally gets around to telling you what the systems proposal is all about. Few readers will have stayed around that long.

Granted, the above examples are pretty extreme, but the same principle applies to many papers that cross your desk. A chronological report may be just the thing for the minutes of a meeting, and deathless prose may stir the soul and fire the spirit, but neither can satisfy the basic purpose of technical communications. This purpose is to inform the busy professional as quickly and as briefly as possible. Even the most dedicated engineer is not seeking entertainment in a technical memo; he wants *first* to know whether the subject is worth his time, *then* the details. Suspense is fine for him on his TV, but not on his job. He wants his technical story backward, conclusion first.

A good rule of thumb is this: If you haven't pretty thoroughly summarized your subject—if the reader doesn't have a good idea of what he's getting—by the end of the first page, then rewrite. From this point on, elaborate, but do so logically. That is, present your major conclusions first, then the supporting details. The result will be selective writing for the most selective of readers, the technical audience. ■

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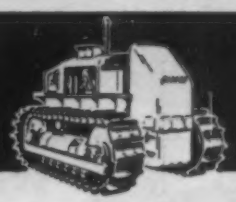

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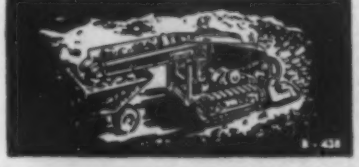

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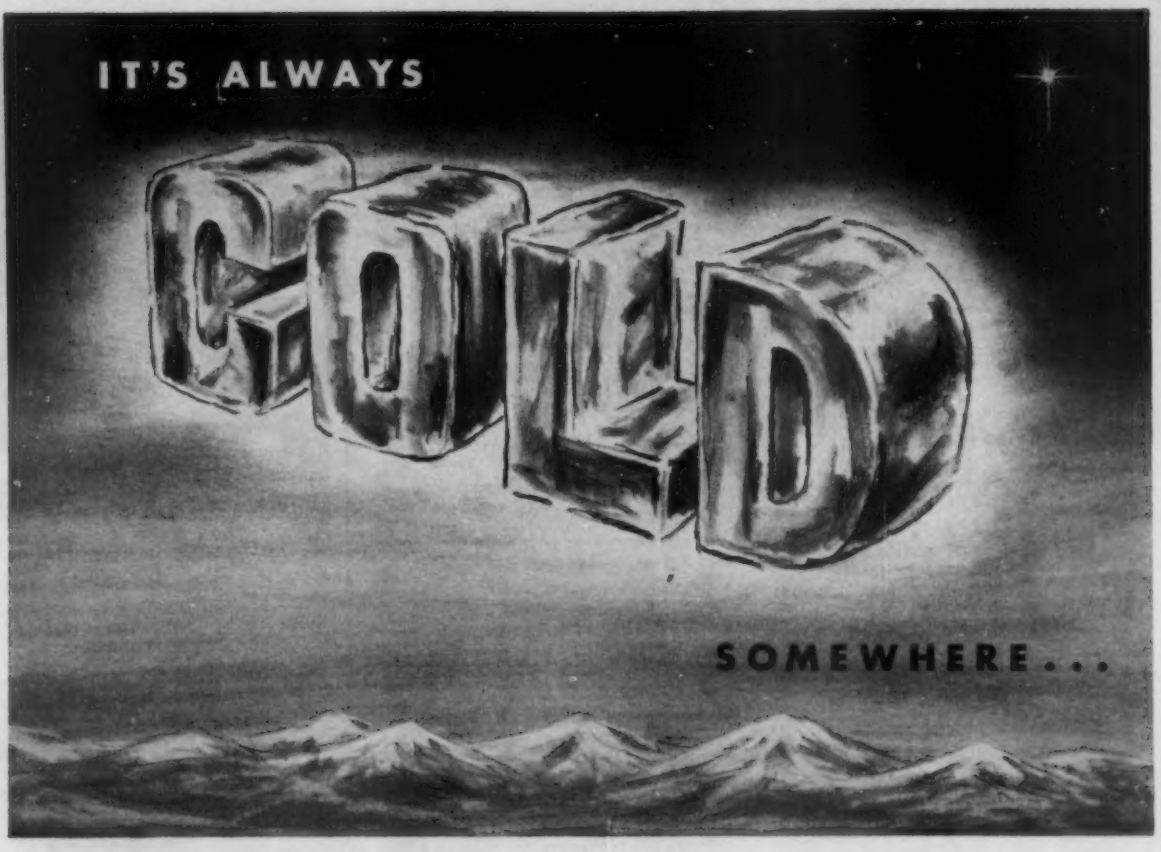

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10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P25 P26 P27 P28 P29 P30 P31 P32 P33 P34
P35 P36 P37 P38 P39 P40 P41 P42 P43 P44

*MULTIPLE PRODUCT ADS

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1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
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16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
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REPRINTS

P25 P26 P27 P28 P29 P30 P31 P32 P33 P34
P35 P36 P37 P38 P39 P40 P41 P42 P43 P44

*MULTIPLE PRODUCT ADS

Key No. Specific Product

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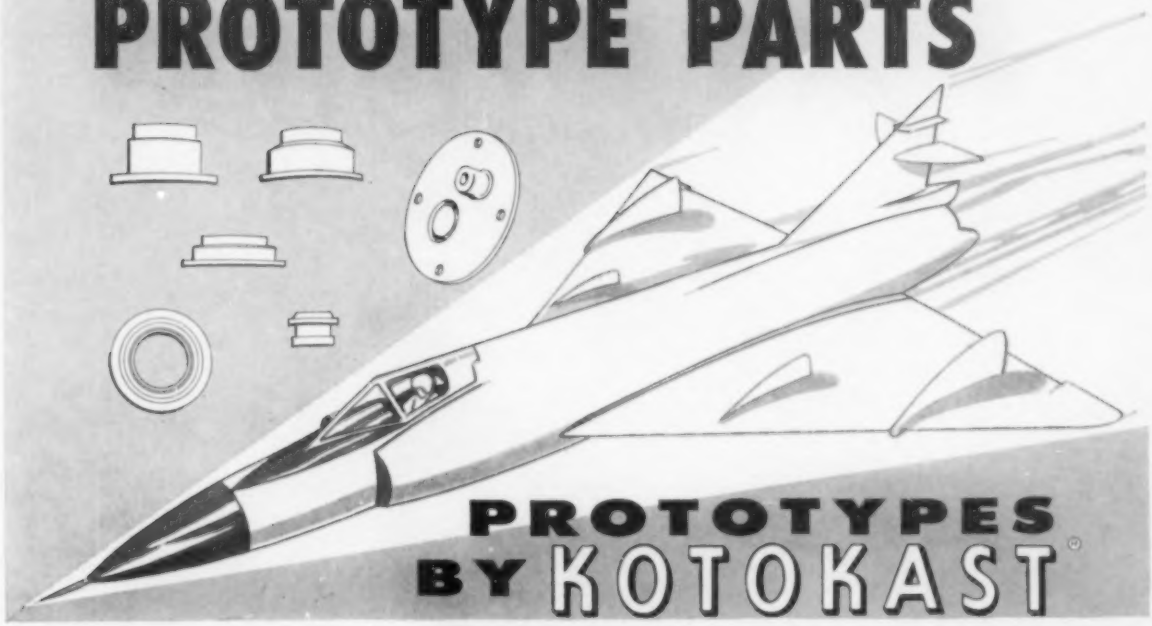

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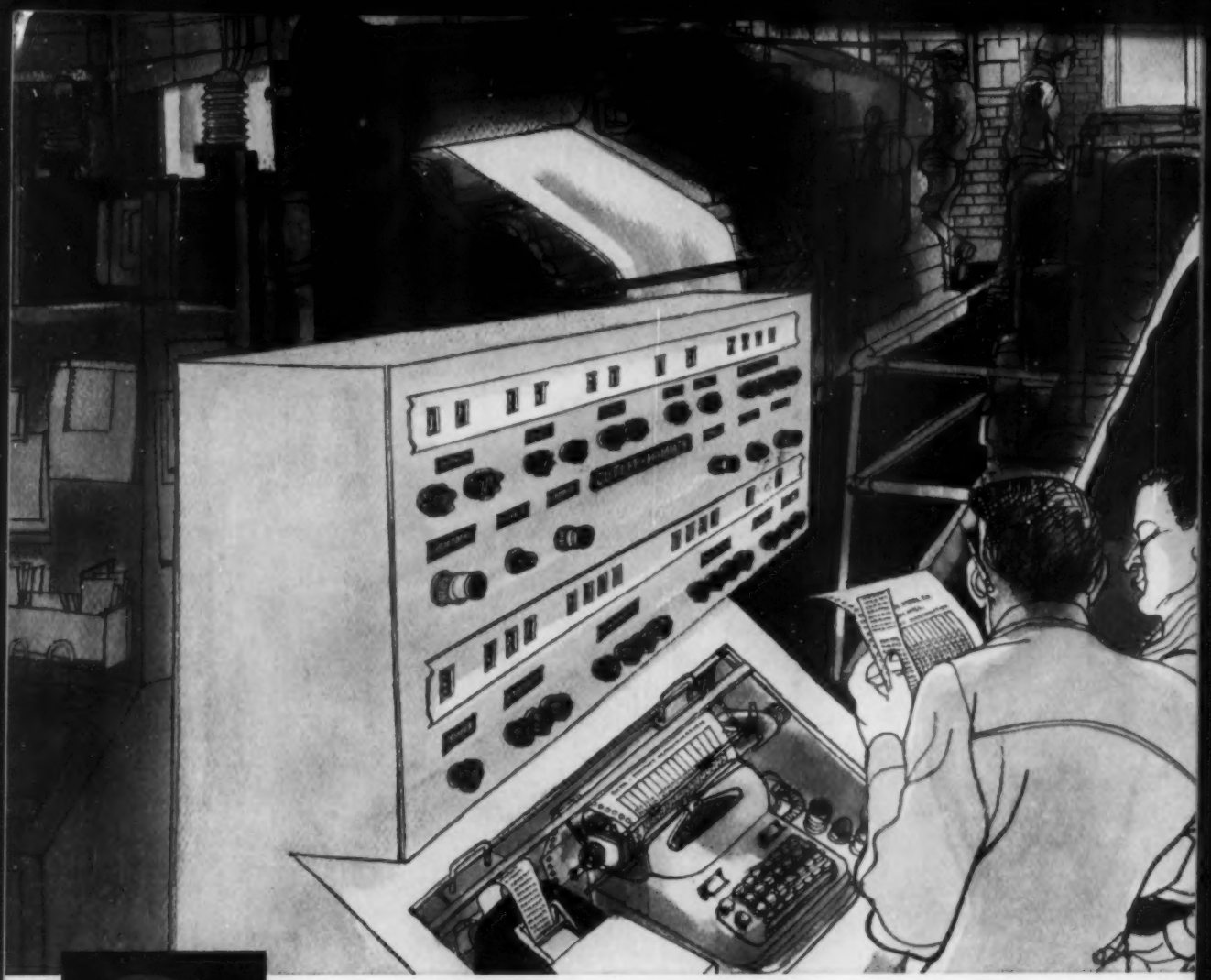

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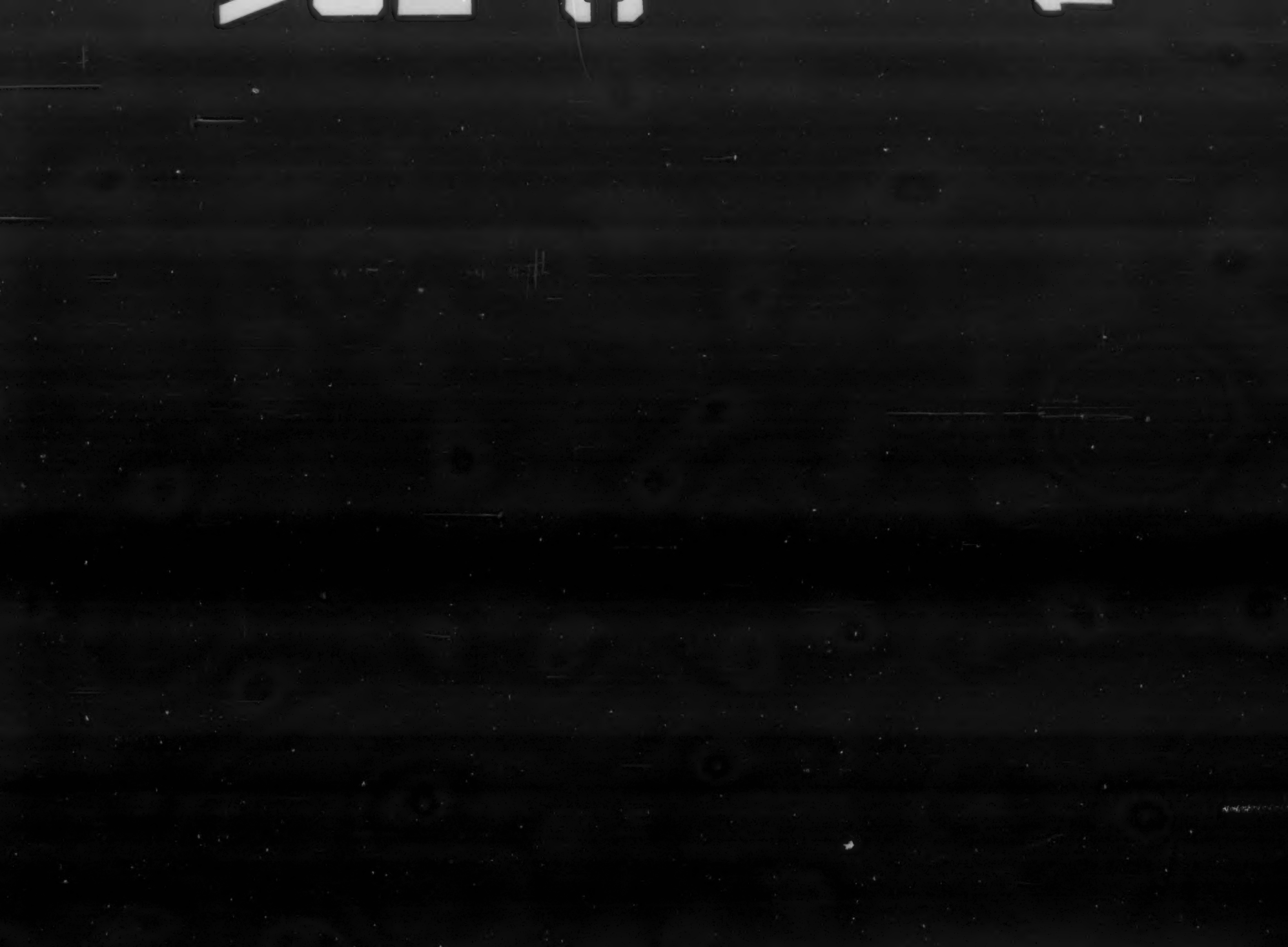
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